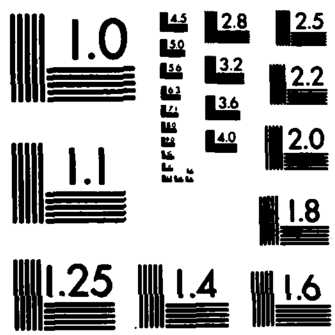
AD-A137 526 TESTING TECHNOLOGY WORKING GROUP REPORT (IDA/OSD R&M (INSTITUTE FOR DEFEN..(U) INSTITUTE FOR DEFENSE ANALYSES ALEXANDRIA VA SCIENCE AND TECH.. G W NEUMANN 1/2

UNCLASSIFIED AUG 83 IDA-D-41 IDA/HQ-83-25924 F/G 15/3 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

HD-E500 613

Copy 10 of 200 copies

(12)

AD A 137526

IDA RECORD DOCUMENT D-41

TESTING TECHNOLOGY WORKING GROUP REPORT (IDA/OSD R&M STUDY)

George W. Neumann
Giordano Associates, Inc.
Working Group Chairman

August 1983

The views expressed within this document are those of the working group only. Publication of this document does not indicate endorsement by IDA, its staff, or its sponsoring agencies.

Prepared for
Office of the Under Secretary of Defense for Research and Engineering
and
Office of the Assistant Secretary of Defense
(Manpower, Reserve Affairs and Logistics)

IDA

INSTITUTE FOR DEFENSE ANALYSES
SCIENCE AND TECHNOLOGY DIVISION

84 01 27 014

IDA Log No. HQ 83-25924

The work reported in this document was conducted under contract MDA 903 79 C 0018 for the Department of Defense. The publication of this IDA Record Document does not indicate endorsement by the Department of Defense, nor should the contents be construed as reflecting the official position of that agency.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A131 526	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Testing Technology Working Group Report (IDA/OSD R&M Study)		5. TYPE OF REPORT & PERIOD COVERED Final July 1982 - August 1983
		6. PERFORMING ORG. REPORT NUMBER IDA Record Document D-41
7. AUTHOR(s) George W. Neumann, Giordano Associates, Inc., Working Group Chairman		8. CONTRACT OR GRANT NUMBER(s) MDA 903 79 C 0018
9. PERFORMING ORGANIZATION NAME AND ADDRESS Institute for Defense Analyses 1801 N. Beauregard Street Alexandria, Virginia 22311		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Task T-2-126
11. CONTROLLING OFFICE NAME AND ADDRESS Office of the Assistant Secretary of Defense (MRA&L), The Pentagon Washington, D.C. 20301		12. REPORT DATE August 1983
		13. NUMBER OF PAGES 136
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) DoD-IDA Management Office 1801 N. Beauregard Street Alexandria, Virginia 22311		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

None

18. SUPPLEMENTARY NOTES

N/A

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

reliability, maintainability readiness, built-in-test (BIT), testability, embedded testing, performance monitoring, automatic test equipment (ATE), fault-tolerant design, diagnostics, prognostics, testing technology, computer aided design

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document records the activities and presents the findings of the Testing Technology Working Group part of the IDA/OSD Reliability and Maintainability Study conducted during the period from July 1982 through August 1983.

DD FORM 1473 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

IDA RECORD DOCUMENT D-41

TESTING TECHNOLOGY WORKING GROUP REPORT (IDA/OSD R&M STUDY)

George W. Neumann
Giordano Associates, Inc.
Working Group Chairman

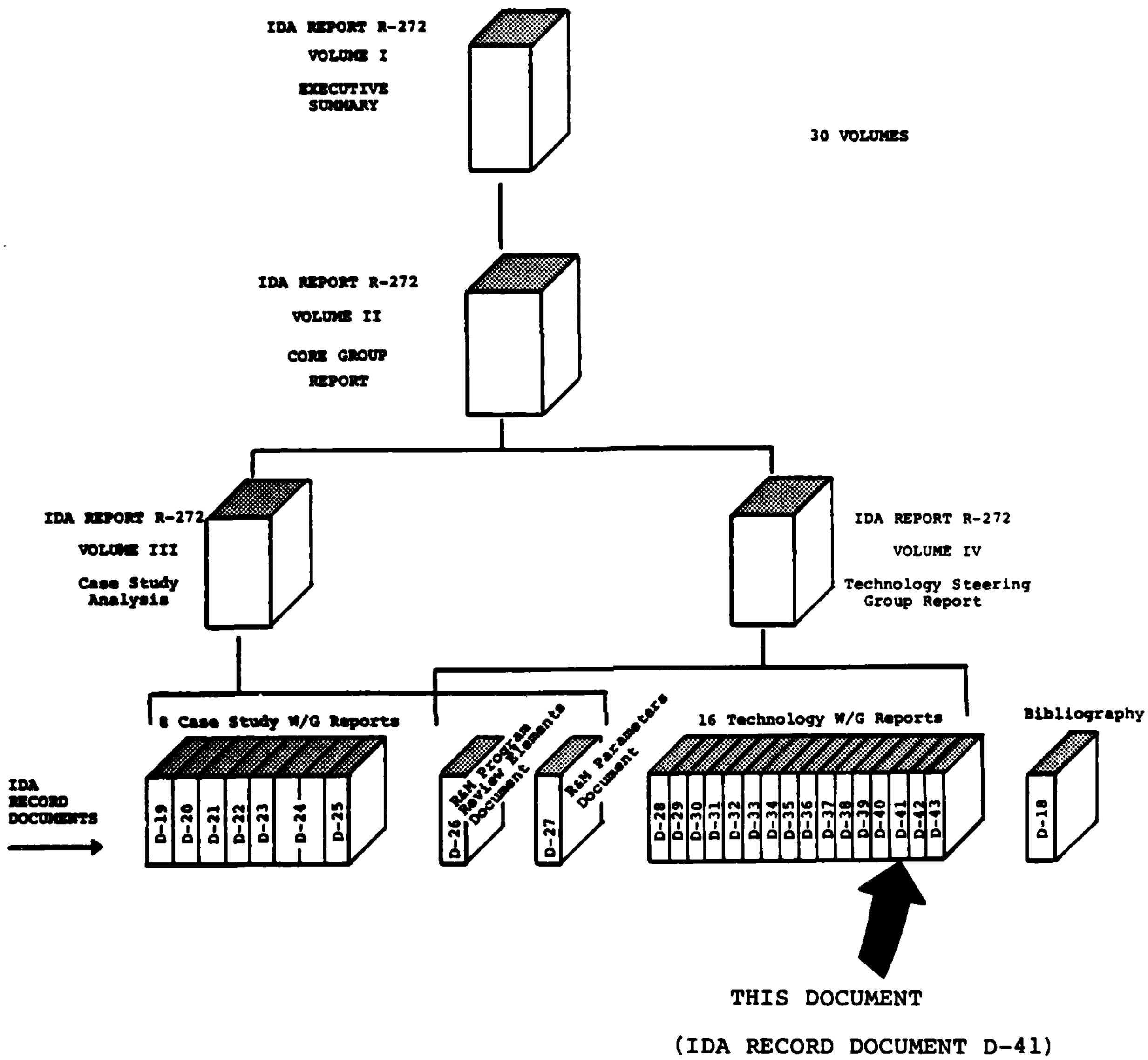
August 1983

INSTITUTE FOR DEFENSE ANALYSES
SCIENCE AND TECHNOLOGY DIVISION
1801 N. Beauregard Street, Alexandria, Virginia 22311
Contract MDA 903 79 C 0018
Task T-2-126

A-1

RELIABILITY AND MAINTAINABILITY STUDY

— REPORT STRUCTURE —



PREFACE

As a result of the 1981 Defense Science Board Summer Study on Operational Readiness, Task Order T-2-126 was generated to look at potential steps toward improving the Material Readiness Posture of DoD (Short Title: R&M Study). This task order was structured to address the improvement of R&M and readiness through innovative program structuring and applications of new and advancing technology. Volume I summarizes the total study activity. Volume II integrates analysis relative to Volume III, program structuring aspects, and Volume IV, new and advancing technology aspects.

The objective of this study as defined by the task order is:

"Identify and provide support for high payoff actions which the DoD can take to improve the military system design, development and support process so as to provide quantum improvement in R&M and readiness through innovative uses of advancing technology and program structure."

The scope of this study as defined by the task order is:

To (1) identify high-payoff areas where the DoD could improve current system design, development program structure and system support policies, with the objective of enhancing peacetime availability of major weapons systems and the potential to make a rapid transition to high wartime activity rates, to sustain such rates and to do so with the most economical use of scarce resources possible, (2) assess the impact of advancing technology on the recommended approaches and guidelines, and (3) evaluate the potential and recommend strategies that might result in quantum increases in R&M or readiness through innovative uses of advancing technology.

The approach taken for the study was focused on producing meaningful implementable recommendations substantiated by quantitative data with implementation plans and vehicles to be provided where practical. To accomplish this, emphasis was placed upon the elucidation and integration of the expert knowledge and experience of engineers, developers, managers, testers and users involved with the complete acquisition cycle of weapons systems programs as well as upon supporting analysis. A search was conducted through major industrial companies, a director was selected and the following general plan was adopted.

General Study Plan

Vol. III	●	Select, analyze and review existing successful program
Vol. IV	●	Analyze and review related new and advanced technology
Vol. II	(●	Analyze and integrate review results
	(●	Develop, coordinate and refine new concepts
Vol. I	●	Present new concepts to DoD with implementation plan and recommendations for application.

The approach to implementing the plan was based on an executive council core group for organization, analysis, integration and continuity; making extensive use of working groups, heavy military and industry involvement and participation, and coordination and refinement through joint industry/service analysis and review. Overall study organization is shown in Fig. P-1.

The basic technology study approach was to build a foundation for analysis and to analyze areas of technology to surface: technology available today which might be applied more broadly; technology which requires demonstration to finalize and reduce risk; and technology which requires action today to provide reliable and maintainable systems in the future. Program structuring implications were also considered. Tools used to accomplish

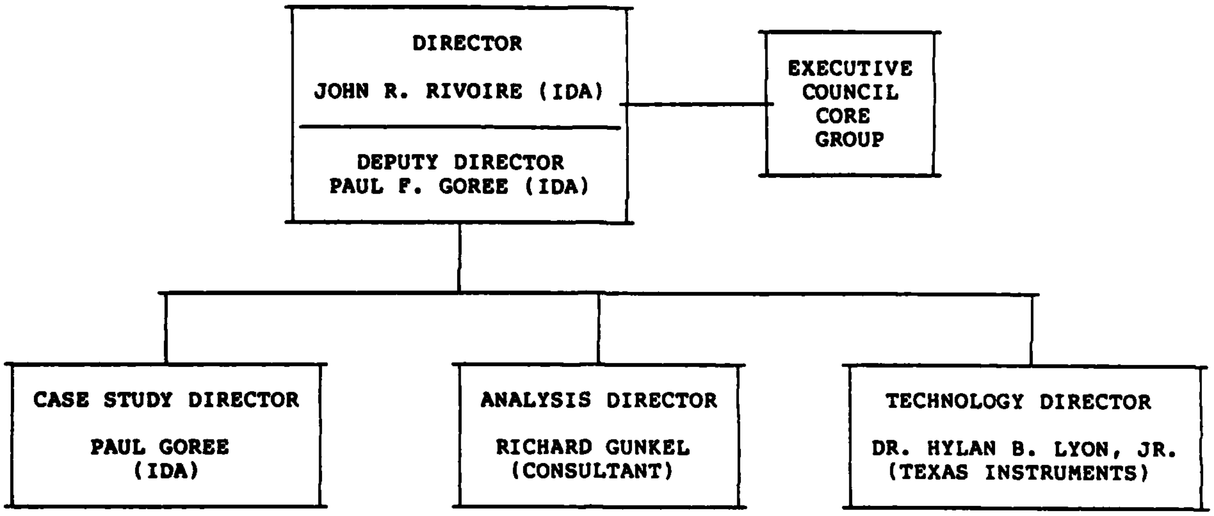


FIGURE P-1. Study Organization

this were existing documents, reports and study efforts such as the Militarily Critical Technologies List. To accomplish the technology studies, sixteen working groups were formed and the organization shown in Fig. P-2 was established.

This document records the activities and findings of the Technology Working Group for the specific technology as indicated in Fig. P-2. The views expressed within this document are those of the working group only. Publication of this document does not indicate endorsement by IDA, its staff, or its sponsoring agencies.

Without the detailed efforts, energies, patience and candidness of those intimately involved in the technologies studied, this technology study effort would not have been possible within the time and resources available.

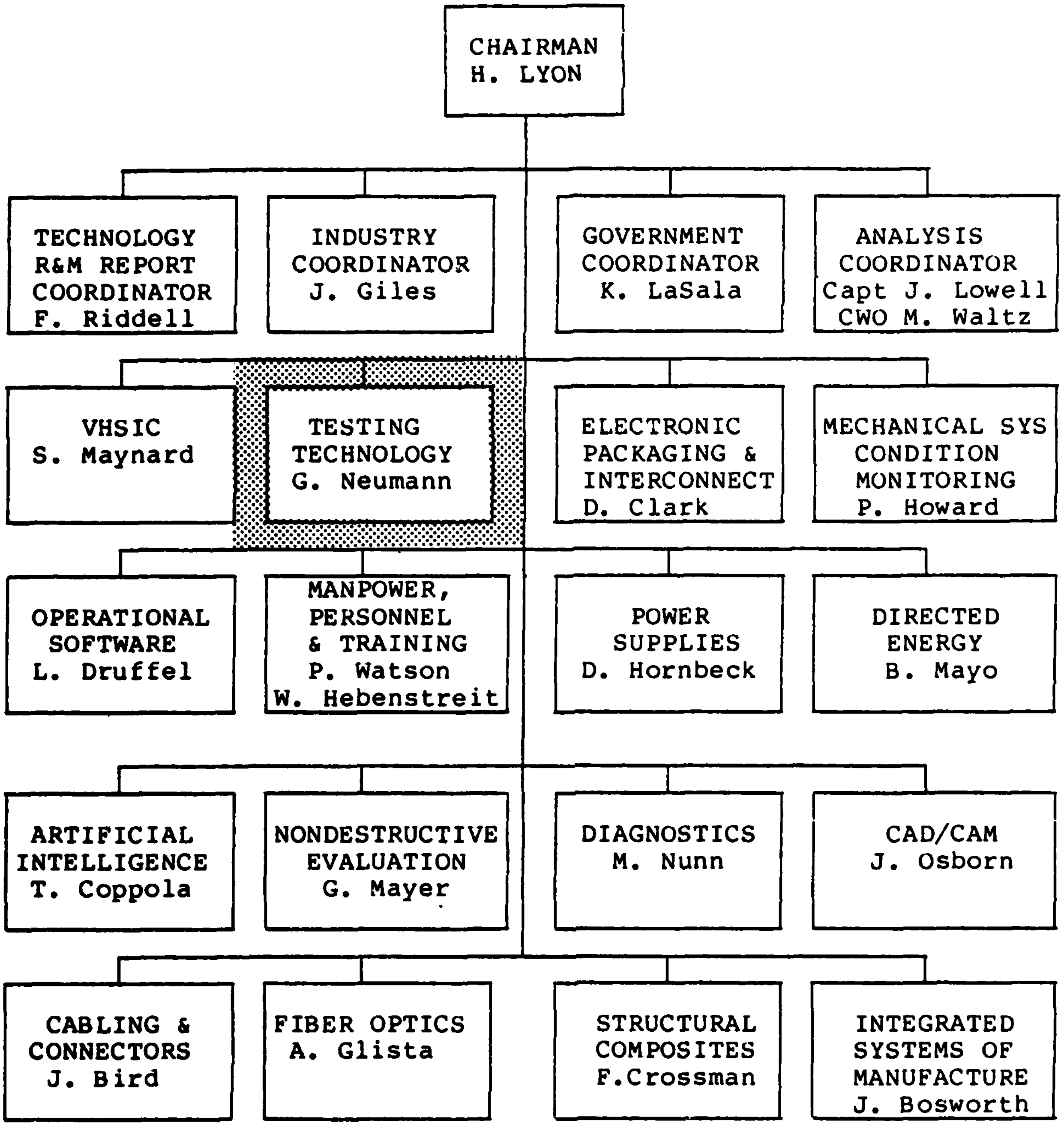


FIGURE P-2. Technology Study Organization

TESTING TECHNOLOGY

(Improving Weapon System Reliability And Maintainability Study Program)

EXECUTIVE SUMMARY

April 1, 1983

George W. Neumann, Chairman
Giordano Associates, Inc.

Mel Nunn
Naval Ocean Systems Center

Robert Bareford
Northrop Corporation

Paul Giordano
Giordano Associates, Inc.

RADM Duncan P. McGillivary, USN
Defense Logistics Agency

The views expressed herein are those of the working group only. Publication of this document does not indicate endorsement by IDA, its staff, or its sponsoring agencies.

FOREWORD

The recognition of the urgent need for a strong DOD Testing Technology Program is not a new idea. In a study, initiated by the Assistant Secretary of the Navy for Research and Development in 1976, a Testing Technology Program was defined. The Navy, through the Naval Ocean Systems Center, put "meat on the bones" and, together with the Navy laboratories and other concerned activities, prepared a Testing Technology Program Plan. Through the JLC Panel On Automatic Testing, the Program was expanded to include the needs of the other Services.

Progress in implementing this Program has been slow. The enthusiasm of the testing technology advocates throughout DOD and industry remains strong. Unfortunately, to a large extent, this enthusiasm has not been effectively transferred to the many layers of management extending from DOD through Congress.

The significant potential for improving the reliability and maintainability by investments in testing technology still remains. It is anticipated that, through this report, the requirement for a strong Testing Technology Program is "laid to rest" and support from Congress, DOD, and the Services ultimately will provide a significant and balanced Program.

The recommendations in this report provide the roadmap for reaching this goal. Sound leadership is required to make this happen.

George W. Neumann
Chairman, Testing Technology Committee

EXECUTIVE SUMMARY

TABLE OF CONTENTS

		Page
Section 1 - Testing Technology		1-1
1.1	Introduction	1-1
1.2	Description Of Entire Reliability And Maintainability Study Program	1-1
1.3	Description Of The Testing Technology	1-3
1.4	Testing Problems In The Field	1-3
1.4.1	Weapon System Testability	1-6
1.4.2	Built-In-Test (BIT)	1-6
1.4.3	Test Equipment	1-8
1.5	Problems In Applying Testing Technology During The Weapon System Acquisition Process	1-8
1.5.1	Advancing Embedded Testing Support Technology	1-8
1.5.2	Applying Testing Technology Early In The Weapon System Acquisition Cycle	1-11
1.5.3	Transitioning Testing Technology	1-11
1.5.4	Utilizing Industry IR&D	1-11
Section 2 - Study Goal And Objectives		2-1
Section 3 - Defining The Requirement		3-1
Section 4 - Testing Technology Requirements		4-1
4.1	Testing Technology	4-1
4.1.1	Weapon System Testability Design Techniques	4-1
4.1.2	On-Line Testing	4-2
4.1.3	Off-Line Testing	4-2
4.1.4	Test Techniques	4-2
4.1.5	Test And Evaluation (Test Beds)	4-2
4.2	Acquisition Tools	4-3
4.3	Management	4-3
4.4	Program Funding	4-3
4.5	Program Priorities	4-5
Section 5 - Conclusions		5-1
5.1	Traditional Weapon System Reliability And Maintainability Design Techniques Are No Longer Satisfactory	5-1
5.2	Improvement In The Technology Is Required	5-1
5.3	Injecting Testing Technology Into Weapon Systems Designs Must Be "Institutionalized"	5-2
5.4	The Management Of Testing Technology Requires Improvement	5-2

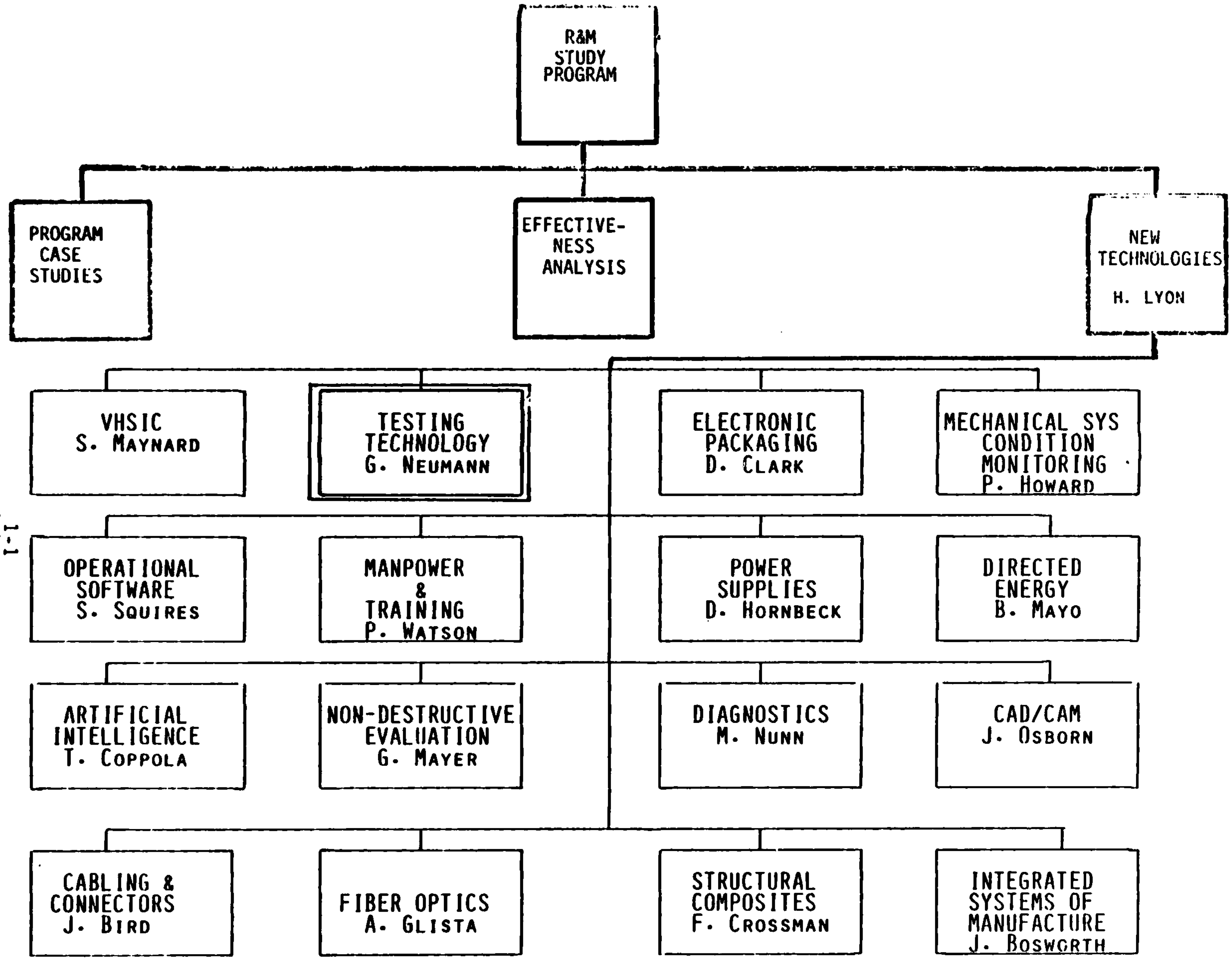
EXECUTIVE SUMMARY

TABLE OF CONTENTS (Continued)

		Page
Section 6 - Recommendations		6-1
6.1	Initiate A Major Weapon System Design Technology Program, Which Injects Testing Technology Into This Design Process	6-1
6.2	Invest In Expanding The Testing Technology Base To Provide "Off-The-Shelf" Proven Alternatives For Use In Weapon System Design	6-1
6.3	Institutionalizing The Transitioning And Utilization Of Testing Technology	6-2
6.4	Initiate A Series Of Actions To Improve Testing Technology Management	6-3

LIST OF ILLUSTRATIONS

Figure No.	Title	Page
1-1	Reliability and Maintainability Study Program Structure	1-2
1-2	Testing Technology Defined	1-4
1-3	Current Problems	1-5
1-4	Comparison of Current and Future Testing Requirements	1-7
1-5	Embedded Test	1-9
1-6	On-Going IR&D Efforts	1-10
1-7	Test Technology in Relation to Weapon System Design	1-12
4-1	Annual Funding Summary ($M)	4-4


R&M STUDY PROGRAM
PROGRAM CASE STUDIES
EFFECTIVE-NESS ANALYSIS
NEW TECHNOLOGIES
H. LYON
VHSIC
S. MAYNARD
TESTING TECHNOLOGY
G. NEUMANN
ELECTRONIC PACKAGING
D. CLARK
MECHANICAL SYS CONDITION MONITORING
P. HOWARD
OPERATIONAL SOFTWARE
S. SQUIRES
MANPOWER & TRAINING
P. WATSON
POWER SUPPLIES
D. HORNBECK
DIRECTED ENERGY
B. MAYO
ARTIFICIAL INTELLIGENCE
T. COPPOLA
NON-DESTRUCTIVE EVALUATION
G. MAYER
DIAGNOSTICS
M. NUNN
CAD/CAM
J. OSBORN
CABLING & CONNECTORS
J. BIRD
FIBER OPTICS
A. GLISTA
STRUCTURAL COMPOSITES
F. CROSSMAN
INTEGRATED SYSTEMS OF MANUFACTURE
J. BOSWORTH

EXECUTIVE SUMMARY

SECTION 1. TESTING TECHNOLOGY

1.1 INTRODUCTION

This study report addresses the requirements for a testing technology development program. The study is part of a larger Reliability and Maintainability Improvement Study Program. The first portion of this report describes this entire study and how testing technology fits into its framework. This is followed by a description of the problem, scope, goals, objectives, approach, content, payoffs, conclusions, and recommendations relating to a testing technology program.

1.2 DESCRIPTION OF ENTIRE RELIABILITY AND MAINTAINABILITY STUDY PROGRAM

The Under Secretary of Defense has initiated a Joint OSD-Service-Industry study for improving weapon system reliability and maintainability (R&M). The objective of the study is to identify and provide support for high payoff actions which DOD can take to improve the military system design, development and support process in the areas of reliability and maintainability, through innovative uses of advancing technology and program structure.

As shown in Figure 1-1, this Joint OSD-Service-Industry study program is divided into three distinct parts. The first part is program case studies to develop a credible list of engineering, design, test and contracting activities, which when followed will satisfy the study objectives. The second part deals with effectiveness analysis in order to quantify the impact of R&M investment. The third part addresses new technologies that could lead to quantum improvements in R&M and readiness.

This report addresses the Testing Technology portion of this third part of the entire Reliability and Maintainability study. Thus, Testing Technology is a sub-subset of New Technologies.

1.3 DESCRIPTION OF THE TESTING TECHNOLOGY

Testing technology covers a gamut of research and development, ranging from basic research (RDT&E category 6.1) to engineering development (RDT&E category 6.4). The technology embraces all weapon system testing needs (e.g., electronics, avionics, propulsion, machinery) related to maintenance of those systems. As shown in Figure 1-2, it includes test equipment; and the logistic support of the equipment, which encompasses two very expensive items - test program sets and the calibration of the test equipment itself. Embedded test support includes built-in-test, readiness monitoring, and system self-alignment. Also included are two technologies which are inexplicably tied to the design of the weapon system. They are: 1) fault-tolerant design techniques, which when used in conjunction with built-in-test, provide a very powerful readiness improvement tool; and, 2) testability design techniques, which enhance the testing of units and systems. Diagnostic and prognostic techniques are an integral part of both test equipment and embedded test support.

The study addresses testing technology required to maintain all types of weapon systems. It does not include such testing as conducted for reliability and maintainability assurance. Development and operational test and evaluation are also excluded. Although not specifically addressing factory testing units during production, the integration of factory and field testing can save significant production, quality assurance, and operational testing man hours.

1.4 TESTING PROBLEMS IN THE FIELD

Testing technology is both a readiness and a life cycle cost driver. It has a significant effect on most of the other ILS elements. It has a significant effect on the combat readiness and operational availability of weapon systems by decreasing Mean Time To Repair and Mean Logistics Delay Time. Used in conjunction with fault-tolerant design techniques, testing technology can significantly increase the Mean Time Between Failures. However, there exist a number of problems which inhibit the effective application of this technology. Some of these problems are summarized in Figure 1-3, and discussed below.

W H A T   I S   I T ?

TESTING TECHNOLOGY

EMBEDDED TEST SUPPORT

- BUILT-IN-TEST (BIT)
- READINESS MONITORING
- SELF-ALIGNMENT
- FAULT TOLERANCE
- TESTABILITY

TEST EQUIPMENT

- AUTOMATIC
- MANUAL
- CALIBRATION

TEST PROGRAM SETS

- TEST PROGRAMS
- INTERFACE DEVICES

- DIAGNOSTICS
- PROGNOSTICS

Figure 1-2. Testing Technology Defined

WHAT IS THE PROBLEM?

TODAY!

	OPERATIONAL READINESS	LCC	MANPOWER
WEAPON SYSTEM TESTABILITY	EXCESSIVE TEST TIME	TPS COST CAN EXCEED $2M / UUT	3 LEVEL MAINTENANCE LOW PRODUCTIVITY
BUILT-IN-TEST	DIAGNOSTIC CAPABILITY 50 - 75%	UNNECESSARY REMOVALS 30 - 70%	FAR > 85%
TEST EQUIPMENT	PROLIFERATION	COSTLY LOGISTIC SUPPORT	TRAINING REQUIREMENTS

Figure 1-3. Current Problems

1.4.1 Weapon System Testability

Weapon systems and their units, which have not been designed to be efficiently tested, create excessive test times, cause excessive diagnostic and test programming costs, and require manpower and skill levels which are not readily available. Test times for units presently fielded which are designed to today's state of the art, can run from a matter of minutes to a number of hours. Figure 1-4 is a comparison of the test requirements for currently available units to that required in the immediate future. In this case, a unit designed with VHSIC devices is used. It is anticipated that maximum operating frequencies for these units will increase by an order of magnitude; the vector depth (memory per pin) will increase by three orders of magnitude; and, using the same testing technology, the overall test times will increase by three orders of magnitude. Test program sets for testing a complex unit, such as a "black box" removed from an aircraft, now can cost over two million dollars each. Test program set costs for units built with VHSIC devices could make the testing of these units impracticable. This lack of designing testable weapon systems and units has forced the military into multi-level maintenance concepts, which require skilled technicians at each maintenance level, has lowered repair productivity, and has resulted in the need for extra spares.

1.4.2 Built-In-Test (BIT)

Built-in-test for weapon systems, which is being introduced into the field today, is not meeting diagnostic specifications. The Air Force Test and Evaluation Center (AFTEC) in a study of three aircraft concluded that the diagnostic capability as seen by the user was in the range of 50 to 75 percent and that the false alarm rate exceeded 85 percent in some instances. In a study conducted by the Naval Sea Systems Command it was found that 70 percent of the modules removed from a weapon system were eventually found to be failure-free. Situations such as these cause the technicians to lose faith in the operation of BIT and causes the logistics system to operate inefficiently.

COMPARISON

	REQUIRED IN THE IMMEDIATE FUTURE	CURRENTLY AVAILABLE
MAXIMUM OPERATING FREQUENCY	100 TO 140 MHz	10 TO 20 MHz
VECTOR DEPTH	1×10^6 TO 4×10^6 BITS PER PIN	1×10^3 TO 4×10^3 BITS PER PIN
OVERALL TEST TIME	3 TO 5 MINUTES	50 TO SEVERAL HUNDRED HOURS FOR SOME VHSIC TYPE UUT

Figure 1-4. Comparison of Current and Future Testing Requirements

1.4.3 Test Equipment

Historically the testing problem has been satisfied by providing both automatic and manual test equipment as the key maintenance and repair tool. This has resulted in the Services fielding three million units of manual test equipment that must be acquired, deployed, and logistically supported. In addition, the Services have procured and deployed approximately 1,000 different types of ATE's, many costing more than a million dollars each. Most of the manual test equipment and many of the building blocks, which make up the ATE's, are commercial units which often times cannot be logistically supported adequately. Training technicians to use this wide variety of test equipment is very difficult and time consuming.

1.5 PROBLEMS IN APPLYING TESTING TECHNOLOGY DURING THE WEAPON SYSTEM ACQUISITION PROCESS

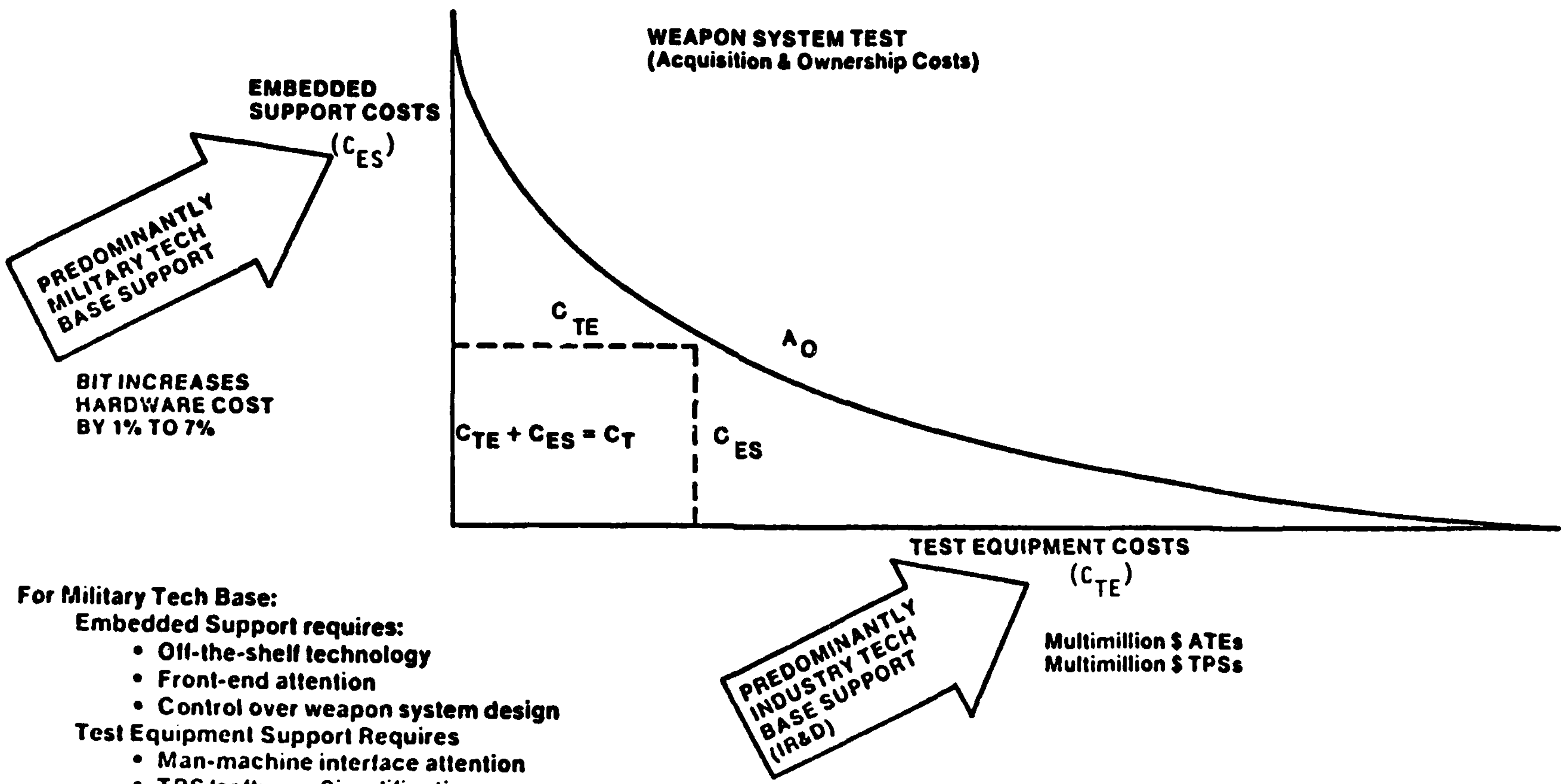
There are a number of problems in applying testing technology during the weapon system acquisition process, which result in excessive life cycle costs. Some of these are described in the following paragraphs.

1.5.1 Advancing Embedded Testing Support Technology

In the past, the emphasis on satisfying testing requirements has been placed on providing more and better test equipment. In most cases, the Services and industry have successfully achieved many advances. However, the same emphasis has not been placed on embedded testing support. Embedded testing support holds promise of reduced costs to achieve a given operational availability. Quite simply, creating the environment a weapon system "sees" in operation is difficult and costly to reproduce in a maintenance shop. As depicted in Figure 1-5, there is a mix of embedded testing and test equipment which will optimally satisfy a given operational availability. This mix is not often achieved.

Each Service has a major research and development in test equipment technology. In addition, industry's IR&D effort is centered on test equipment hardware and software simply because this is what they can market. Industry cannot readily market embedded testing support and so there is little IR&D in this area. Figure 1-6 graphically depicts the effort which more than 30 companies sponsor over a hundred different projects, probably

THE PROBLEM



For Military Tech Base:

Embedded Support requires:

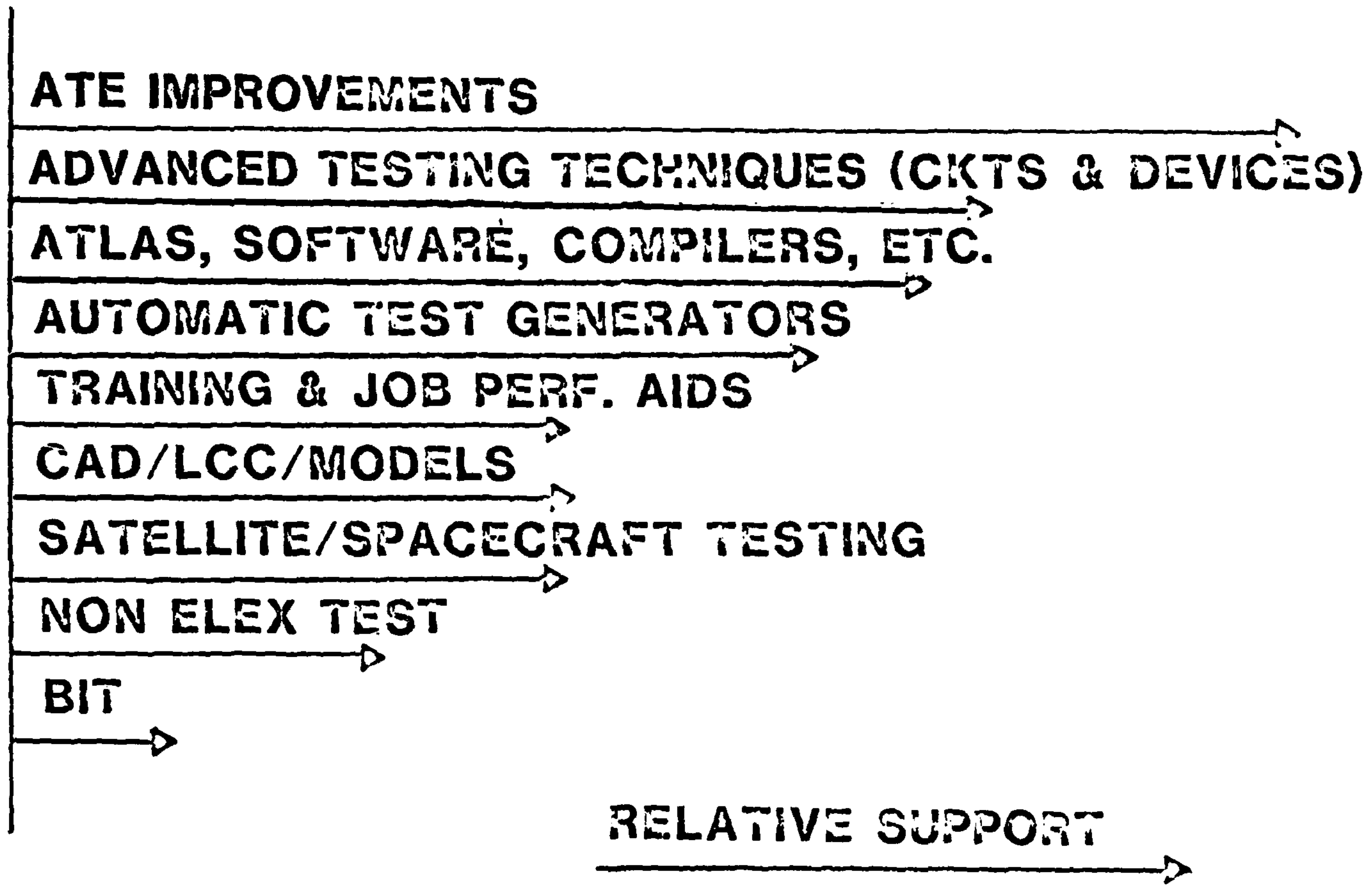
- Off-the-shelf technology
- Front-end attention
- Control over weapon system design

Test Equipment Support Requires

- Man-machine interface attention
- TPS/software Simplification
- Control over ATE proliferation
- Embedded support for test equipment

Figure 1-5. Embedded Test

INDEPENDENT RESEARCH & DEVELOPLMENT



- 30 COMPANIES
- OVER 100 TASKS

Figure 1-6. On-Going IR&D Efforts

with a dollar value of 10 to 20 million dollars per year. Only a fraction of these dollars are spent on embedded testing support technology. Embedded testing support requires development of "off-the-shelf" technology, which is ready to apply at the early stages of weapon systems design, as a rigorous design discipline.

1.5.2 Applying Testing Technology Early In The Weapon System Acquisition Cycle

Historically, prime system designers have generally regarded maintenance (including testing) and logistic support as an after-design concept. In addition, prime contractors do not adequately and properly communicate to subcontractors the scope and depth of testability required. Neither is there an adequate acceptance test program to evaluate the degree of subcontractor testability conformance. As a result, the Services have been playing catch-up while many of their weapon systems are down. Testing technology must be an integral part of weapon system design. As depicted in Figure 1-7, this technology is closely tied to computer-aided design, logistic support analysis and the automation of diagnostics, test and maintenance. Without this "front-end" attention, investments in testing technology can provide only marginal returns in readiness and cost reduction.

1.5.3 Transitioning Testing Technology

Traditionally, transitioning technology in any field has been difficult. Transitioning technology from basic research to exploratory development to advanced development and to engineering development causes problems, because often each of these RDT&E categories is managed by a separate organizational entity. For the same reason, it has proved difficult to transition testing technology to weapon system design.

1.5.4 Utilizing Industry IR&D

Industry's IR&D investment in testing technology is significant. OSD and the Services have emphasized the need for additional IR&D in each one of the logistic support elements. Without better incentives, improved coordination, and follow-on visibility, much of this industry effort remains unused.

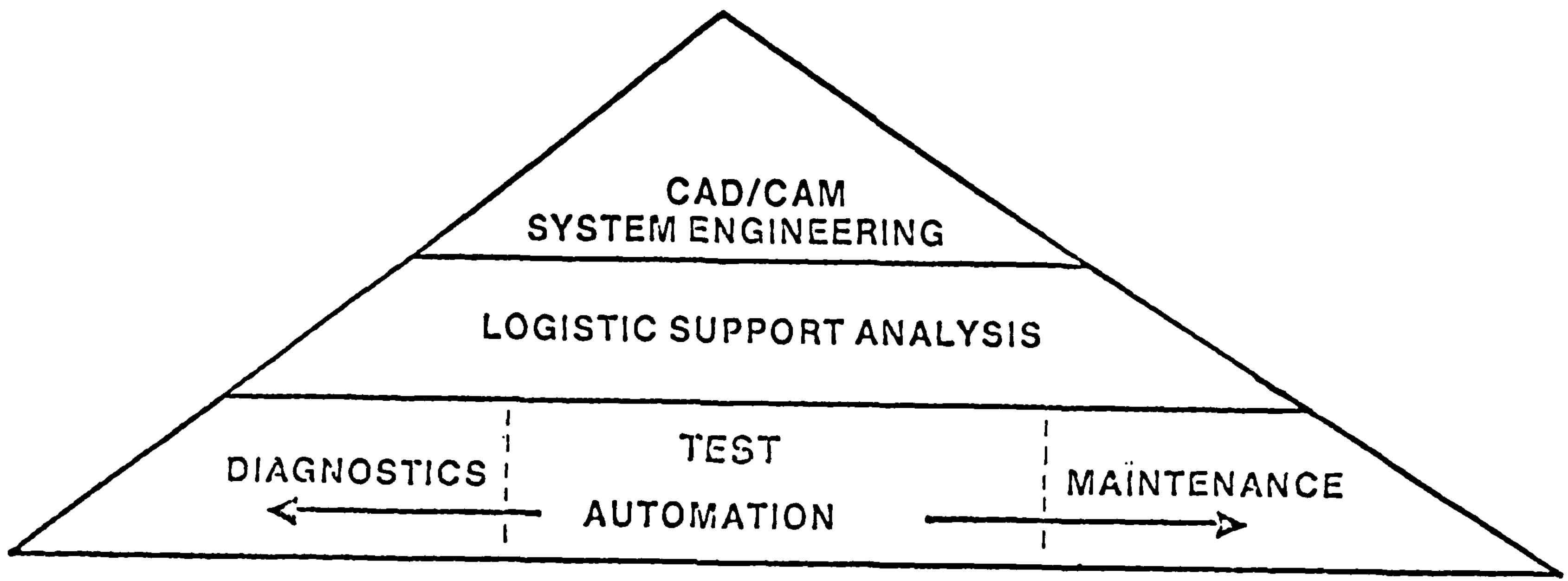


Figure 1-7. Test Technology in Relation to Weapon System Design

SECTION 2. STUDY GOAL AND OBJECTIVES

The objectives of this Testing Technology Study are to:

- o Identify the required technology development.
- o Estimate the impacts of thest technology developments.
- o Identify the key management actions required to support the development and application of this technology.
- o Prepare the detailed analysis necessary to justify and defend the priorities that must be afforded this technology and the expected payoffs.

SECTION 3. DEFINING THE REQUIREMENT

Over the past few years the Services and industry have taken a number of significant steps toward defining the requirements for testing technology .

The Navy's program was established as a result of a study directed by the Assistant Secretary of the Navy for Research and Development 1976. This study was culminated in a "Report On Navy Issues Concerning Automatic Test, Monitoring, And Diagnostic Systems And Equipment". This Report identified 20 basic Fleet problems in automatic testing and proposed 14 solutions. The Navy's Testing Technology Program today is based on the findings of this study.

Two or three years later, the Air Force initiated the Modular ATE (MATE) Program. This was a major concept definition program in competition between Sperry and Westinghouse. One of the outputs of this conceptual effort was a set of MATE guides dealing with virtually every aspect of automatic testing and testability. These guides are being used by the Air Force in the acquisition of their automatic testing hardware and software.

The Army has just concluded, within the past year, a DATAT[1] study, which resulted in 22 findings which addressed all aspects of test, measurement, and diagnostic equipment. This study has formed the basis for the Army's technological and managerial approach to solving testing problems.

In 1981 the Assistant Secretary of Defense, Manpower, Reserve Affairs and Logistics sponsored a Built-In-Test Equipment Requirements Workshop. This Workshop was held for the purpose of assessing progress and problems in specifying and evaluating built-in-test used in complex electronic equipment. A number of significant recommendations resulted from this Workshop. These recommendations are documented in the Institute for Defense Analysis Paper, P-1600. Fourteen of these recommendations dealt with specifying and evaluating diagnostics, including built-in-test. Another set of recommendations were made, which clearly identified the need for technology development in built-in-test and diagnostic techniques. This study formed the basis for a DOD-wide program to improve built-in-test and diagnostics.

---

1 Department of the Army Test, Measurement and Diagnostic Equipment Action Team.

Defining and coordinating testing technology effort among the Services is being accomplished through the framework of the Joint Logistics Commanders (JLC). The JLC Panel On Automatic Testing was formed in 1978 and coordinates and guides the Joint Services Automatic Testing program. One of the useful testing technology assessments was developed under this Joint Service Automatic Testing program. It assesses future testing technology needs[2]. This report evaluates the impact of new technologies on testing technology requirements. It also determines the applicability of these new technologies to solving test problems. The report covers new technology in systems, components, electromagnetic transmissions, computers, electro-optics, and acoustics.

Testability, as a defined discipline, has been in being for the last five or six years. However, the institutionalization of testability, including the ability to invoke testability requirements in our weapon systems designs to assure that requirements are met, is in its infancy. Through a Built-In-Test/Testability Improvement Program, initiated under the Joint Service program, the path for institutionalizing testability through a series of standardization documents, which are closely tied to the logistics support analysis process, has been defined. In addition, R&D has been recommended to develop, modify, and evaluate a series of testability analytical tools to aid designers in performing testability trade-offs.

On the other hand, industry has played an important part in defining the Services' testing technology program. Two comprehensive studies have been supported by five industry associations: The Aerospace Industries Association; The Electronic Industries Association; The National Security Industrial Association; The Shipbuilders Council Of America; and, The American Electronics Association. The first of these studies culminated in a "Report Of Industry Ad Hoc Automatic Test Equipment Project For The Navy". This study was directed almost totally at defining RDT&E needs in testing technology and the institutionalization of their use. A similar

2 NOSC TD 426, Technology Assessment, 1980, Forecast Of Future Test Technology Requirements (March, 1981).

type project for the Joint Services was subsequently undertaken by these five industrial organizations. The Final Report of this "Industry/Joint Services Automatic Test Project" addressed the entire spectrum of automatic testing.

Because of the close working relationship between the Services and industry during this period, the Services' testing technology programs are totally compatible with the industry recommendations.

SECTION 4. TESTING TECHNOLOGY REQUIREMENTS

Investing in testing technology does little good if the Services do not provide a means for weapon system designers to easily use this technology. A three-pronged approach to this problem is indicated. This includes: 1) development of the technology itself, coupled with; 2) the tools used to apply this technology in the weapon system acquisition process; and, 3) appropriate management attention to ensure proper utilization. Each of these three items is addressed in this Section.

4.1 TESTING TECHNOLOGY

The composition of required testing technology includes the need for weapon system testability design techniques. All of these revolve around the concept of a test bed supported with advanced development funds to evaluate combinations of testing technologies, while being able to ascertain the synergistic effects of each.

4.1.1 Weapon System Testability Design Techniques

Testability is defined as a design characteristic which allows the status (operable, inoperable, or degraded) of a unit (system, subsystem, module, or component) to be confidently determined in a timely fashion. Testability is inherently a weapon system design issue. At present, the use of computerized tools in the design of a weapon system is not an integrated process. The design of the weapon system itself is part of the computer-aided design (CAD) process. Logistics support analysis (LSA) for ILS should support this CAD process, with testability as a major driver. However, testability as a rigorous design technique is in its infancy. Means for specifying, predicting, and demonstrating weapon system testability are not mature.

The reliability of deployed weapon systems has not proved satisfactory. Traditional reliability approaches are expensive, time consuming, and not altogether satisfactory. Fault-tolerant design techniques mainly have centered around restructuring at the equipment level, which is costly and creates a greater maintenance workload. Present effort in development of fault-tolerant design techniques is fractionated with little thought on "institutionalizing" its use.

4.1.2 On-Line Testing

On-line testing is defined as testing a weapon system or unit in its operational environment. It includes built-in-test, built-in-test equipment, performance monitoring, status monitoring, maintenance aiding, etc. Whether on-line testing is at the ship level, the aircraft level, the vehicle level or the weapon system level, it involves "designing-in" a comprehensive testing hardware and software capability during the acquisition process.

4.1.3 Off-Line Testing

Off-line testing is accomplished by a combination of automatic and manual test equipment, coupled with the necessary software for test program sets required to diagnose faulty units. Development of manual test equipment required by the Services is being accomplished by industry, using IR&D funds. Except in special cases, the Services do not and should not invest their dollars to develop manual test equipment. On the other hand, automatic test equipment, to a large degree, is designed to the operational and support requirements of the Services. Logistic support (including calibration) is required for all types of test equipment.

4.1.4 Test Techniques

The extensive, and sometimes unnecessary, maintenance actions on weapon systems place high demands on personnel and test equipment, and adversely affect combat readiness. Furthermore, the employment of new and emerging technologies, which offer opportunities for reducing manning requirements for future weapon system operation, will impose increased demands on maintenance personnel. Test techniques are required to satisfy these demands.

4.1.5 Test And Evaluation (Test Beds)

None of the technology development discussed in the above paragraphs can be developed in a vacuum. Scientific test beds, including prototypes, need to be utilized for use in evaluating various testing technology improvements in an integrated, realistic operating environment.

4.2 ACQUISITION TOOLS

Applying the output of testing technology requires the institutionalization of acquisition tools. These include:

a. Preparation of design and application guides, standards and specifications for weapon system designers.

b. Establishment and maintenance of informational data banks for use with analytical models.

c. Development and offering of educational courses for project managers and weapon system designers in the application of testing technology.

4.3 MANAGEMENT

Transitioning test technology to weapon system design requires a number of management initiatives.

a. An organizational entity is required within each Service and OSD to plan, coordinate and transition testing technology through to weapon system design.

b. Policy directives are required for each Service to establish such an organization and to assure technology developments are funded and pursued.

c. Controls over development of testing technology and its application are required.

d. Methods for Joint Service coordination of testing technology is required.

4.4 PROGRAM FUNDING

Figure 4-1 is a funding summary, which indicates that basic research and exploratory development is funded at $7M annually - 50 percent of requirements. Advanced and engineering developments are funded at $27M - 77 percent of requirements. This does not include a substantial deficit in the Navy's Consolidated Support System out-year funding.

ANNUAL FUNDING SUMMARY ($M)

	PRESENT LEVEL		ANNUAL REQUIREMENT		ANNUAL DEFICIENCY	
	6.1 / 6.2	6.3 / 6.4	6.1 / 6.2	6.3 / 6.4	6.1 / 6.2	6.3 / 6.4
WEAPON SYSTEM $\bar{T}$ DESIGN	1	0	2	1	1	1
ON-LINE TESTING	1	2	3	6	2	4
OFF-LINE TESTING	2	25	4	25	2	0
TEST TECHNIQUES	3	0	5	1	2	1
TEST BED	N/A	N/A	0	2	0	2
TOTAL	7	27	14	35	7	8

6.1 / 6.2 = 50% OF REQUIREMENTS
6.3 / 6.4 = 77% OF REQUIREMENTS*
* DOES NOT INCLUDE CSS OUT YEAR FUNDING DEFICIENCY

Figure 4-1. Annual Funding Summary ($M)

4.5 PROGRAM PRIORITIES

The various parts of the Testing Technology Program have been prioritized based on test issues; the affect on weapon system operational readiness, life cycle cost and manpower considerations; technical risk; and the size of the funding deficiency. High priorities are given to:

- Weapon system design, using testability/BIT/fault tolerance/performance monitoring techniques, incorporated into the CAD/LSA process.
- Diagnostic/prognostic techniques, integrating FMEA, BIT/Testability maintenance aiding, ATPG into a cohesive, institutionalized process.
- Non-electronic test and monitoring techniques.
- System-level test techniques.

SECTION 5. CONCLUSIONS

As a result of this study, the following conclusions have been reached.

5.1 TRADITIONAL WEAPON SYSTEM RELIABILITY AND MAINTAINABILITY DESIGN TECHNIQUES ARE NO LONGER SATISFACTORY

Traditional design techniques for injecting reliability and maintainability technology into weapon systems are no longer satisfactory. Testability and testing requirements must be injected into weapon system operational requirements, requests for proposals, and system specifications beginning at the weapon systems concept formulation stage and continuing throughout the acquisition cycle. These requirements must be specified as "design requirements" and measurable over the acquisition cycle of the weapon system. To accomplish this, we must learn to "speak the language" of the weapon system designer. A "performance over time" concept must replace the "supportability" concept, with "performance over time" equal in importance to performance capability. Effectiveness must have the relationship between performance capability and "performance over time":

$$E \approx P_C \times P_T.$$

To do this, we must learn how to specify P_T. It must be mission-driven and relatable to acquisition and ownership costs.

5.2 IMPROVEMENT IN THE TECHNOLOGY BASE IS REQUIRED

The present technology base does not exist to significantly improve this situation. Tools do not exist to integrate and trade-off various reliability, maintainability and testability elements. While continuing support of off-line testing RDT&E is essential, more emphasis should be placed on embedded testing support, which offers the promise of simplifying the logistics pipeline and minimizing the amount of external test equipment. The era of VHSIC on the horizon necessitates significant investments in testing technology, prior to their use in fielded systems. Means for predicting and demonstrating testing technology payoffs are not sophisticated enough to ascertain their value and to convince weapon systems designers of their utility.

5.3 INJECTING TESTING TECHNOLOGY INTO WEAPON SYSTEMS DESIGNS MUST BE "INSTITUTIONALIZED"

Institutionalizing the injection of testing technology into weapon system designs is not being satisfactorily accomplished. Project managers and their counterparts in industry are not ready to risk involvement in inventing and applying this technology. The analytical tools, documentation, data bases, and educational courses are not adequate to promote across-the-board application of testing technology.

5.4 THE MANAGEMENT OF TESTING TECHNOLOGY REQUIRES IMPROVEMENT

The management of testing technology is not satisfactory and is a major barrier to the success of the program. Responsibility is fractionated both within OSD and within the Services. Over 100 testing technology tasks with 25 different sponsors and 51 performing activities supported by 27 different program elements are symptoms of the problem. The Services are attempting to improve this situation to the degree possible under existing policy and procedures. Both the Navy and the Army have established Testing Technology Strategy Teams to coordinate and guide their programs. All three Services have central focal points for coordination of testing technology effort, but normally do not exert control over the funding. This lack of a home for testing technology is reflected in lack of support for testing technology and clearly inhibits its transitioning from one RDT&E category to the next and, subsequently, its utilization in weapon systems. The funding for testing technology is approximately 50 percent of what is required. At present, testing technology funding support is much less than 1 percent of what is being spent in the testing area today. Industry IR&D is not aimed at solving this problem, but yet is key to solving the transitioning problem; and thus, must be given additional incentives, guidance, and controls to make this happen.

SECTION 6. RECOMMENDATIONS

The following paragraphs are the major recommendations emanating from this study.

6.1 INITIATE A MAJOR WEAPON SYSTEM DESIGN TECHNOLOGY PROGRAM, WHICH INJECTS TESTING TECHNOLOGY INTO THIS DESIGN PROCESS

A major weapon system design technology must be initiated, which injects testing technology into this design process. Methods must be developed for specifying mission-driven testing requirements beginning with weapon system operational requirements and proceeding through the weapon system acquisition cycle. These requirements must be specified as both performance capability and "performance over time" parameters. Tools which can quantify the return on investment for various testing technology alternatives and permit trading-off to determine the proper mix of test strategies, technologies, and equipment must be developed. Measures of effectiveness to quantify the effect of these mixes on operational readiness and manpower requirements are required. This process must be incorporated into the weapon system computer-aided design/logistic support analysis process to insure proper application. Design techniques, which promote testability, must be developed, along with the ability to predict and demonstrate testability quantitatively.

6.2 INVEST IN EXPANDING THE TESTING TECHNOLOGY BASE TO PROVIDE "OFF-THE-SHELF" PROVEN ALTERNATIVES FOR USE IN WEAPON SYSTEM DESIGN

The testing technology base needs to be expanded to provide Government and industry project managers with "off-the-shelf" proven alternatives for use in their designs. Embedded test support should be emphasized including:

a. Development of non-electronic monitoring systems and diagnostic/prognostic techniques.

b. Development of system-level (end-to-end) testing techniques, coupled with operational training procedures as a means for automating effective maintenance, reducing manual testing, and providing on-the-job training.

c. Development of performance monitoring hardware and software to provide command with an information tool for ascertaining the readiness of his weapon systems.

Support of the three Service off-line ATE programs (MATE, CSS, and ATSS) should continue, as an example of successfully transitioning testing technology to advanced and engineering development, and subsequent application to weapon systems.

A formal Integrated Diagnostics program with a goal of 100 percent planned fault detection and fault isolation is required. The present Air Force and Navy emphasis on this concept should be further expanded and adopted by the other Services. This concept is supported by the recommendations emanating from the OSD BIT Workshop and the NSIA Integrated Diagnostics Conference, and thus has both the Service and industry recognition. Issuance of formal OSD and Service policy is required, along with auditing procedures to insure proper implementation. In addition, RDT&E is required for development of BIT technology including "smart BIT", pin electronics, etc. The comprehensive research and development in maintenance aiding should continue with emphasis placed on implementing this technology as an integral part of Integrated Diagnostics. Procedures to promote diagnostic consistency from factory testing through all maintenance and training levels should be developed.

The testing of advanced devices such as VHSIC, bubble memories, charge-coupled devices, etc., should be addressed prior to being incorporated in weapon system designs. Calibration techniques for both manual and automatic testing equipment need to be developed to lessen the calibration load and reduce calibration costs.

Lastly, the test bed concept, supported by a significant advanced development effort, needs to be formalized as a means for synergistically demonstrating and integrating test technology.

6.3 INSTITUTIONALIZING THE TRANSITIONING AND UTILIZATION OF TESTING TECHNOLOGY

To institutionalize transitioning and use of testing technology, it is required that:

a. The series of guidance documents, standards, specifications, and handbooks listed in Table 4-2 of the basic report must be modified or prepared, as appropriate, for use in the weapon system acquisition process.

b. The testing technology data bases presently available for use are not adequate. Data is required as an input to P_T, return on investment, and testability prediction models. Data to estimate the payoffs from investments in technology is required. Testability feedback of field data is required as a means for updating mission-driven testing requirements.

c. The present Service- and industry-offered courses in automatic testing acquisition and design for testability need to be expanded. In addition, a course of ATLAS (IEEE Std. 716) is required.

6.4 INITIATE A SERIES OF ACTIONS TO IMPROVE TESTING TECHNOLOGY MANAGEMENT

The following is a series of required actions to improve the development and application of testing technology:

a. Current management of testing technology RDT&E is fractionated. A single managerial network of testing technology advocates is required extending from OSD through the individual military Services. A single Service manager is not required, but rather a series of focal points beginning at OSD and extending through the lowest managerial levels in the Services, each with appropriate control of funding. These focal points not only should be charged with the responsibility for the testing technology program for their organization, but also have appropriate implementation authority to assure proper application of this technology. They should be charged with "sign-off" authority at appropriate design review points.

b. Integration of testing technology into an overall logistics RDT&E program is required. Fewer program elements, improved integration of logistic effort supported within these program elements and an established schedule for development and transitioning this technology are integral parts of this process.

c. DOD Directives and Instructions 5000.1, 5000.2, and 5000.39, etc., and the Service implementing instructions and regulations should be reviewed to assure adequate attention is paid to testing technology. In particular, testability, as a rigorous design discipline, should be injected into these policy documents. Each Service and OSD should be charged with this review responsibility, with a rigorous schedule established for modification and preparation of appropriate policy documents.

d. A program needs to be established and funded to identify weapon system "bad actors" and take action to improve the reliability and maintainability of these units. Periodic reports should be prepared on the progress being made.

e. Finally, improved incentives for IR&D in testing technology are required. Credit for IR&D effort into proposals should be recognized when evaluating these contractors' proposals.

TESTING TECHNOLOGY

(Improving Weapon System Reliability And Maintainability Study Program)

April 1, 1983

George W. Neumann, Chairman
Giordano Associates, Inc.

Mel Nunn
Naval Ocean Systems Center

Robert Bareford
Northrop Corporation

Paul Giordano
Giordano Associates, Inc.

RADM Duncan P. McGillivary, USN
Defense Logistics Agency

The views expressed herein are those of the working group only. Publication of this document does not indicate endorsement by IDA, its staff, or its sponsoring agencies.

58/2-1

FOREWORD

The recognition of the urgent need for a strong DOD Testing Technology Program is not a new idea. In a study, initiated by the Assistant Secretary of the Navy for Research and Development in 1976, a Testing Technology Program was defined. The Navy, through the Naval Ocean Systems Center, put "meat on the bones" and, together with the Navy laboratories and other concerned activities, prepared a Testing Technology Program Plan. Through the JLC Panel On Automatic Testing, the Program was expanded to include the needs of the other Services.

Progress in implementing this Program has been slow. The enthusiasm of the testing technology advocates throughout DOD and industry remains strong. Unfortunately, to a large extent, this enthusiasm has not been effectively transferred to the many layers of management extending from DOD through Congress.

The significant potential for improving the reliability and maintainability by investments in testing technology still remains. It is anticipated that, through this report, the requirement for a strong Testing Technology Program is "laid to rest" and support from Congress, DOD, and the Services ultimately will provide a significant and balanced Program.

The recommendations in this report provide the roadmap for reaching this goal. Sound leadership is required to make this happen.

George W. Neumann
Chairman, Testing Technology Committee

TABLE OF CONTENTS

		Page
Section 1 - Testing Technology		1-1
1.1	Introduction	1-1
1.2	Description Of Entire Reliability And Maintainability Study Program	1-1
1.3	Description Of The Testing Technology	1-3
1.4	Testing Problems In The Field	1-3
1.4.1	Weapon System Testability	1-6
1.4.2	Built-In-Test (BIT)	1-6
1.4.3	Test Equipment	1-8
1.5	Problems In Applying Testing Technology During The Weapon System Acquisition Process	1-8
1.5.1	Advanced Embedded Testing Support Technology	1-8
1.5.2	Applying Testing Technology Early In The Weapon System Acquisition Cycle	1-11
1.5.3	Transitioning Testing Technology	1-11
1.5.4	Utilizing Industry IR&D	1-11
Section 2 - Study Goal And Objectives		2-1
Section 3 - Defining The Requirement		3-1
Section 4 - Testing Technology Requirements		4-1
4.1	Testing Technology	4-1
4.1.1	Weapon System Testability Design Techniques	4-4
4.1.1.1	Computer-Aided Design/Testability Design Tools	4-15
4.1.1.2	LSA Process	4-15
4.1.1.3	Testability Prediction And Demonstration	4-16
4.1.1.4	BIT/MTE/ATE/FOMS	4-17
4.1.1.5	Fault-Tolerant Design	4-18
4.1.2	On-Line Testing	4-18
4.1.2.1	Performance Monitoring	4-18
4.1.2.2	Built-In-Test	4-19
4.1.2.3	Maintenance Aids	4-19A
4.1.2.4	Non-Electronic Monitoring	4-20
4.1.3	Off-Line Testing	4-21
4.1.3.1	Automatic Test Equipment (ATE)	4-21
4.1.3.2	Applications Software (TPS)	4-22
4.1.3.3	Automatic Test Program Generation (ATPG)	4-22
4.1.3.4	Metrology/Calibration	4-23
4.1.4	Test Techniques	4-23
4.1.4.1	Diagnostics/Prognostics	4-24
4.1.4.2	Advanced Device And Non-Conventional Testing	4-25
4.1.4.3	System-Level Testing	4-25
4.1.5	Test And Evaluation (Test Beds)	4-26
4.2	Acquisition Tools	4-27
4.3	Management	4-27
4.4	Program Summary	4-30
4.4.1	Program Funding	4-30
4.4.2	Program Priorities	4-30
4.4.3	The Interface Of Testing Technology With Other Technologies	4-48

TABLE OF CONTENTS (Continued)

		Page
Section 5 - Benefits Analysis And Technology Payoffs Of Testing Technology		5-1
5.1	Common Denominator Is Cost Reduction	5-1
5.2	Operational Requirements Must Call Out Performance Vs. Time	5-1
5.3	Trade-Offs Driven By Cost	5-2
5.4	Productivity Is Key To Cost Reduction	5-3
5.4.1	Japanese Model	5-3
5.4.2	Return On Investment Drives U.S. Decisions	5-4
5.5	Diagnostics Drives Cost Reduction	5-5
5.6	Specific Benefits And Payoffs	5-5
5.6.1	Embedded Test Support	5-12
5.6.1.1	Maintenance Benefits	5-12
5.6.1.2	Productivity Improvements And Factory Testing Benefits	5-15
5.6.2	Productivity Gains Through Off-Line Testing	5-16
5.6.3	Summary Of Benefits	5-16
Section 6 - Conclusions		6-1
6.1	Traditional Weapon System Reliability And Maintainability Design Techniques Are No Longer Satisfactory	6-1
6.2	Improvement In The Technology Is Required	6-1
6.3	Injecting Testing Technology Into Weapon Systems Designs Must Be "Institutionalized"	6-2
6.4	The Management Of Testing Technology Requires Improvement	6-2
Section 7 - Recommendations		7-1
7.1	Initiate A Major Weapon System Design Technology Program, Which Injects Testing Technology Into This Design Process	7-1
7.2	Invest In Expanding The Testing Technology Base To Provide "Off-The-Shelf" Proven Alternatives For Use In Weapon System Design	7-1
7.3	Institutionalizing The Transitioning And Utilization Of Testing Technology	7-2
7.4	Initiate A Series Of Actions To Improve Testing Technology Management	7-3
	Bibliography	B-1

LIST OF ILLUSTRATIONS

Figure No.	Title	Page
1-1	Reliability and Maintainability Study Program Structure	1-2
1-2	Testing Technology Defined.	1-4
1-3	Current Problems.	1-5
1-4	Comparison of Current and Future Testing Requirements.	1-7
1-5	Embedded Test	1-9
1-6	On-Going IR&D Efforts	1-10
1-7	Test Technology in Relation to Weapon System Design.	1-12
4-1	Automatic Testing Program	4-2
4-2	Testing Technology Program Structure.	4-3
4-3	Sponsors of Testing Technology.	4-31
4-4	Performing Activities	4-32
4-5	Testing Technology Program Elements	4-33
4-6	Annual Funding Summary ($M)	4-46
4-7	Relative Priorities	4-47
4-8	Testing Technology Interfaces With Other Technologies.	4-49
5-1	O&MN $ For Component Repair	5-6
5-2	A-6E/EA-6B Repair Costs	5-7
5-3	S-3A Repair Costs	5-8
5-4	F-14 Repair Costs	5-9
5-5	FA-18 Repair Costs	5-10
5-6	O&MN $ For Component Repair	5-11
5-7	On-Line Testing (Payoff).	5-14

LIST OF TABLES

Table No.	Title	Page
4-1	Summary of Testing Technology Tasks	4-5
4-2	Institutionalizing Test Technology.	4-28
4-3	Summary of Testing Technology Requirements and Status	4-34

SECTION 1. TESTING TECHNOLOGY

1.1 INTRODUCTION

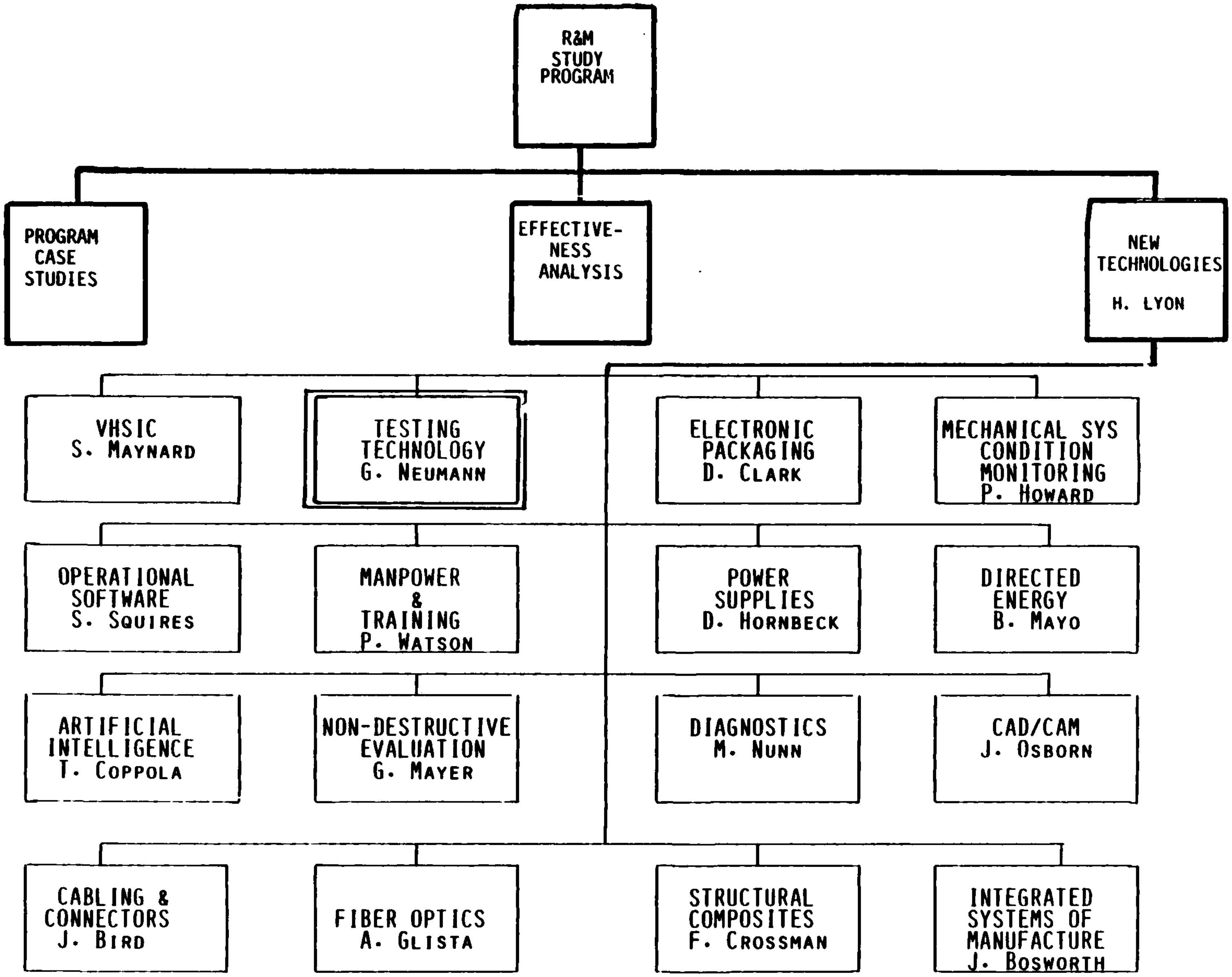
This study report addresses the requirements for a testing technology development program. The study is part of a larger Reliability and Maintainability Improvement Study Program. The first portion of this report describes this entire study and how testing technology fits into its framework. This is followed by a description of the problem, scope, goals, objectives, approach, content, payoffs, conclusions, and recommendations relating to a testing technology program.

1.2 DESCRIPTION OF ENTIRE RELIABILITY AND MAINTAINABILITY STUDY PROGRAM

The Under Secretary of Defense has initiated a Joint OSD-Service-Industry study for improving weapon system reliability and maintainability (R&M). The objective of the study is to identify and provide support for high payoff actions which DOD can take to improve the military system design, development and support process in the areas of reliability and maintainability, through innovative uses of advancing technology and program structure. The study approach is to:

- Select, analyze and review existing successful programs
- Analyze and review the related new and advancing technology
- Analyze and integrate review results
- Develop, coordinate and refine new concepts
- Present new concepts to DOD with recommendations for implementation.

As shown in Figure 1-1, this Joint OSD-Service-Industry study program is divided into three distinct parts. The first part is program case studies to develop a credible list of engineering, design, test and contracting activities, which when followed will satisfy the study objectives. The second part deals with effectiveness analysis in order to quantify the impact of R&M investment. The third part addresses new technologies that could lead to quantum improvements in R&M and readiness.


R&M STUDY PROGRAM
PROGRAM CASE STUDIES
EFFECTIVE-NESS ANALYSIS
NEW TECHNOLOGIES
H. LYON
VHSIC
S. MAYNARD
TESTING TECHNOLOGY
G. NEUMANN
ELECTRONIC PACKAGING
D. CLARK
MECHANICAL SYS CONDITION MONITORING
P. HOWARD
OPERATIONAL SOFTWARE
S. SQUIRES
MANPOWER & TRAINING
P. WATSON
POWER SUPPLIES
D. HORNBECK
DIRECTED ENERGY
B. MAYO
ARTIFICIAL INTELLIGENCE
T. COPPOLA
NON-DESTRUCTIVE EVALUATION
G. MAYER
DIAGNOSTICS
M. NUNN
CAD/CAM
J. OSBORN
CABLING & CONNECTORS
J. BIRD
FIBER OPTICS
A. GLISTA
STRUCTURAL COMPOSITES
F. CROSSMAN
INTEGRATED SYSTEMS OF MANUFACTURE
J. BOSWORTH

This report addresses the Testing Technology portion of this third part of the entire Reliability and Maintainability study. Thus, Testing Technology is a sub-subset of New Technologies.

1.3 DESCRIPTION OF THE TESTING TECHNOLOGY

Testing technology covers a gamut of research and development, ranging from basic research (RDT&E category 6.1) to engineering development (RDT&E category 6.4). The technology embraces all weapon system testing needs (e.g., electronics, avionics, propulsion, machinery) related to maintenance of those systems. As shown in Figure 1-2, it includes test equipment; and the logistic support of the equipment, which encompasses two very expensive items - test program sets and the calibration of the test equipment itself. Embedded test support includes built-in-test, readiness monitoring, and system self-alignment. Also included are two technologies which are inexplicably tied to the design of the weapon system. They are: 1) fault-tolerant design techniques, which when used in conjunction with built-in-test, provide a very powerful readiness improvement tool; and, 2) testability design techniques, which enhance the testing of units and systems. Diagnostic and prognostic techniques are an integral part of both test equipment and embedded test support.

The study addresses testing technology required to maintain all types of weapon systems. It does not include such testing as conducted for reliability and maintainability assurance. Development and operational test and evaluation are also excluded. Although not specifically addressing factory testing units during production, the integration of factory and field testing can save significant production, quality assurance, and operational testing man hours.

1.4 TESTING PROBLEMS IN THE FIELD

Testing technology is both a readiness and a life cycle cost driver. It has a significant effect on most of the other ILS elements. It has a significant effect on the combat readiness and operational availability of weapon systems by decreasing Mean Time To Repair and Mean Logistics Delay Time. Used in conjunction with fault-tolerant design techniques, testing technology can significantly increase the Mean Time Between Failures. However, there exist a number of problems which inhibit the effective application of this technology. Some of these problems are summarized in Figure 1-3, and discussed below.

WHAT IS IT ?

TESTING TECHNOLOGY

EMBEDDED TEST SUPPORT
- BUILT-IN-TEST (BIT)
- READINESS MONITORING
- SELF-ALIGNMENT
- FAULT TOLERANCE
- TESTABILITY

TEST EQUIPMENT
- AUTOMATIC
- MANUAL
- CALIBRATION

TEST PROGRAM SETS
- TEST PROGRAMS
- INTERFACE DEVICES

- DIAGNOSTICS
- PROGNOSTICS

Figure 1-2. Testing Technology Defined

WHAT IS THE PROBLEM?

TODAY!

	OPERATIONAL READINESS	LCC	MANPOWER
WEAPON SYSTEM TESTABILITY	EXCESSIVE TEST TIME	TPS COST CAN EXCEED \$2M / UUT	3 LEVEL MAINTENANCE LOW PRODUCTIVITY
BUILT-IN-TEST	DIAGNOSTIC CAPABILITY 50 - 75%	UNNECESSARY REMOVALS 30 - 70%	FAR > 85%
TEST EQUIPMENT	PROLIFERATION	COSTLY LOGISTIC SUPPORT	TRAINING REQUIREMENTS

Figure 1-3. Current Problems

1.4.1 Weapon System Testability

Weapon systems and their units, which have not been designed to be efficiently tested, create excessive test times, cause excessive diagnostic and test programming costs, and require manpower and skill levels which are not readily available. Test times for units presently fielded which are designed to today's state of the art, can run from a matter of minutes to a number of hours. Figure 1-4 is a comparison of the test requirements for currently available units to that required in the immediate future. In this case, a unit designed with VHSIC devices is used. It is anticipated that maximum operating frequencies for these units will increase by an order of magnitude; the vector depth (memory per pin) will increase by three orders of magnitude; and, using the same testing technology, the overall test times will increase by three orders of magnitude. Test program sets for testing a complex unit, such as a "black box" removed from an aircraft, now can cost over two million dollars each. Test program set costs for units built with VHSIC devices could make the testing of these units impracticable. This lack of designing testable weapon systems and units has forced the military into multi-level maintenance concepts, which require skilled technicians at each maintenance level, has lowered repair productivity, and has resulted in the need for extra spares.

1.4.2 Built-In-Test (BIT)

Built-in-test for weapon systems, which is being introduced into the field today, is not meeting diagnostic specifications. The Air Force Test and Evaluation Center (AFTEC) in a study of three aircraft concluded that the diagnostic capability as seen by the user was in the range of 50 to 75 percent and that the false alarm rate exceeded 85 percent in some instances. In a study conducted by the Naval Sea Systems Command it was found that 70 percent of the modules removed from a weapon system were eventually found to be failure-free. Situations such as these cause the technicians to lose faith in the operation of BIT and causes the logistics system to operate inefficiently.

COMPARISON

	REQUIRED IN THE IMMEDIATE FUTURE	CURRENTLY AVAILABLE
MAXIMUM OPERATING FREQUENCY	100 TO 140 MHz	10 TO 20 MHz
VECTOR DEPTH	1×10^6 TO 4×10^6 BITS PER PIN	1×10^3 TO 4×10^3 BITS PER PIN
OVERALL TEST TIME	3 TO 5 MINUTES	50 TO SEVERAL HUNDRED HOURS FOR SOME VHSIC TYPE UUT

Figure 1-4. Comparison of Current and Future Testing Requirements

1.4.3 Test Equipment

Historically the testing problem has been satisfied by providing both automatic and manual test equipment as the key maintenance and repair tool. This has resulted in the Services fielding three million units of manual test equipment that must be acquired, deployed, and logistically supported. In addition, the Services have procured and deployed approximately 1,000 different types of ATE's, many costing more than a million dollars each. Most of the manual test equipment and many of the building blocks, which make up the ATE's, are commercial units which often times cannot be logistically supported adequately. Training technicians to use this wide variety of test equipment is very difficult and time consuming.

1.5 PROBLEMS IN APPLYING TESTING TECHNOLOGY DURING THE WEAPON SYSTEM ACQUISITION PROCESS

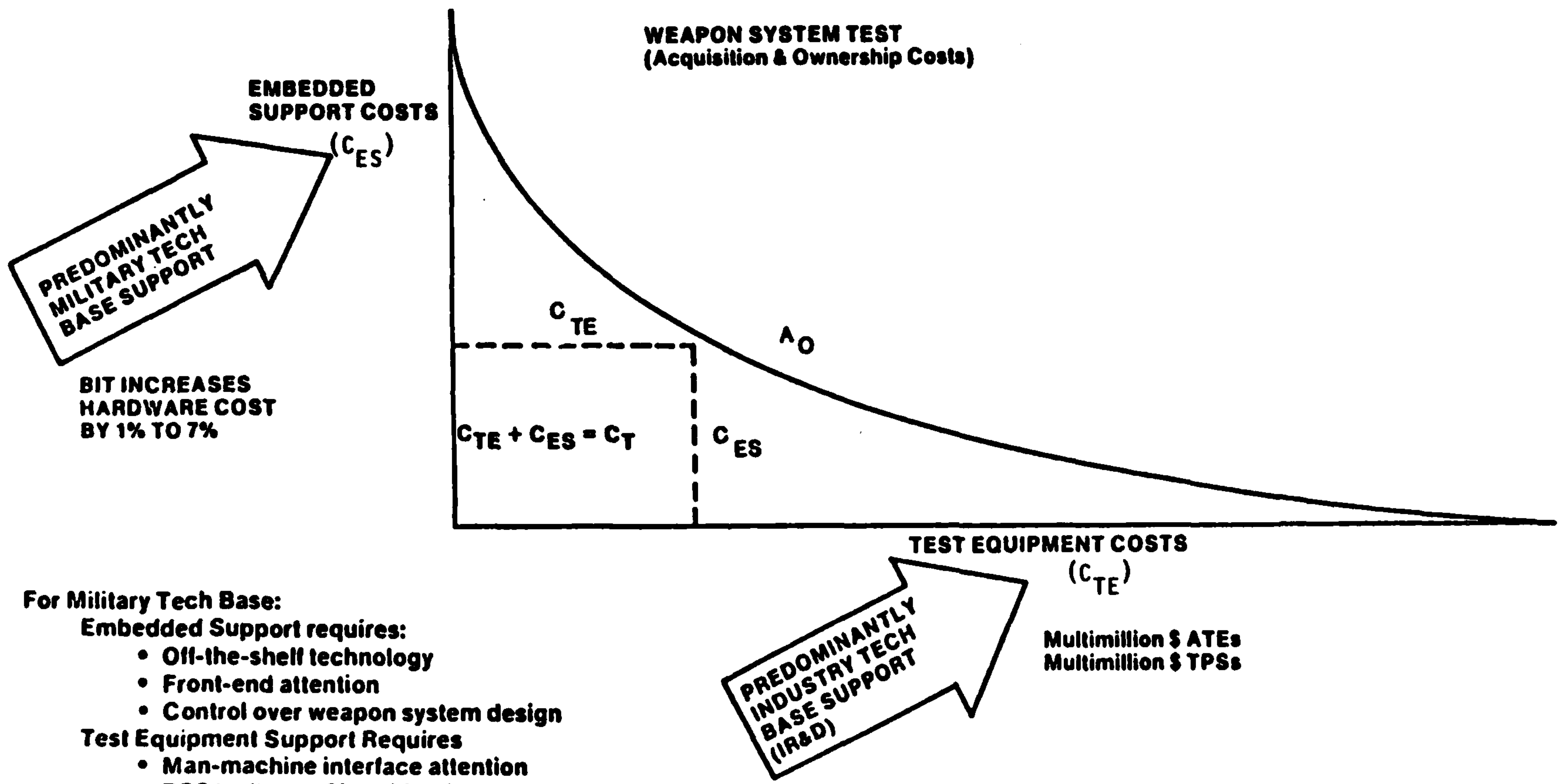
There are a number of problems in applying testing technology during the weapon system acquisition process, which result in excessive life cycle costs. Some of these are described in the following paragraphs.

1.5.1 Advancing Embedded Testing Support Technology

In the past, the emphasis on satisfying testing requirements has been placed on providing more and better test equipment. In most cases, the Services and industry have successfully achieved many advances. However, the same emphasis has not been placed on embedded testing support. Embedded testing support holds promise of reduced costs to achieve a given operational availability. Quite simply, creating the environment a weapon system "sees" in operation is difficult and costly to reproduce in a maintenance shop. As depicted in Figure 1-5, there is a mix of embedded testing and test equipment which will optimally satisfy a given operational availability. This mix is not often achieved.

Each Service has a major research and development in test equipment technology. In addition, industry's IR&D effort is centered on test equipment hardware and software simply because this is what they can market. Industry cannot readily market embedded testing support and so there is little IR&D in this area. Figure 1-6 graphically depicts the effort which more than 30 companies sponsor over a hundred different projects, probably

THE PROBLEM



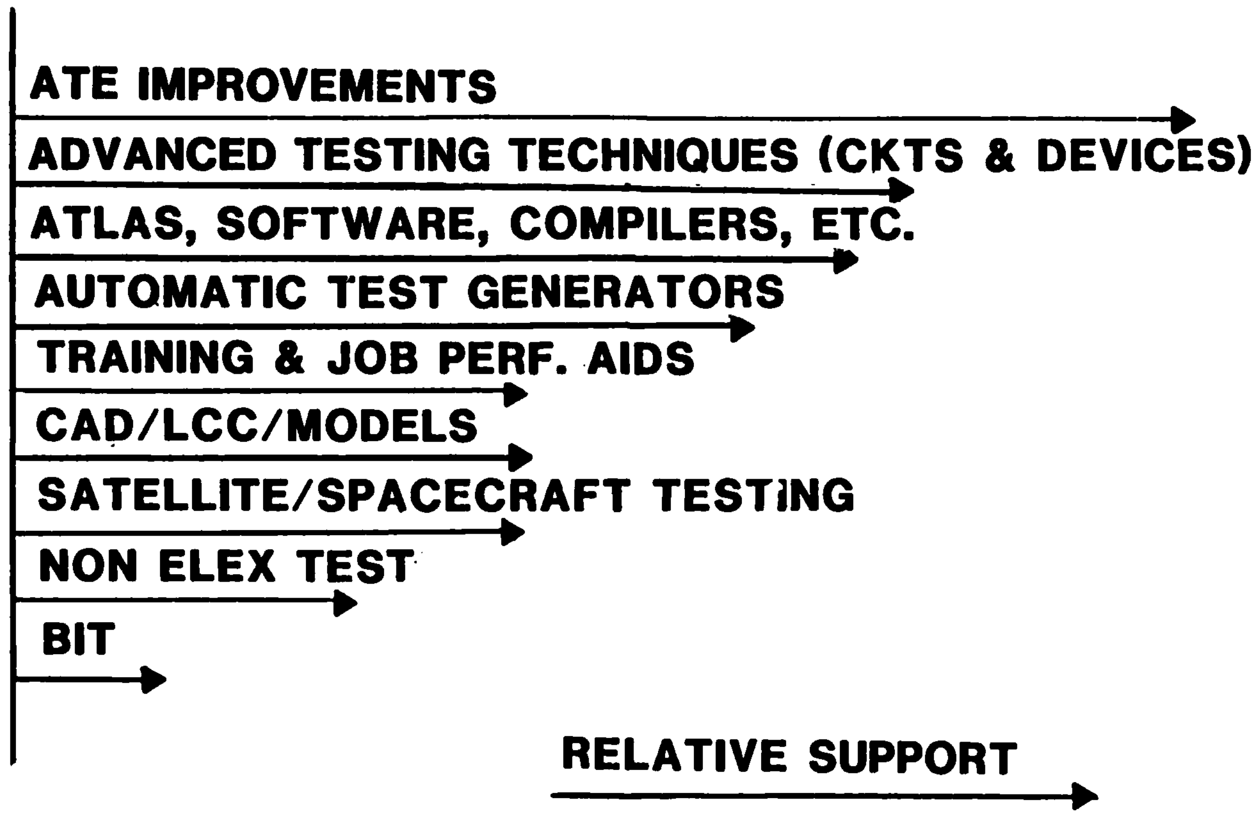
For Military Tech Base:

Embedded Support requires:
- Off-the-shelf technology
- Front-end attention
- Control over weapon system design

Test Equipment Support Requires
- Man-machine interface attention
- TPS/software Simplification
- Control over ATE proliferation
- Embedded support for test equipment

Figure 1-5. Embedded Test

INDEPENDENT RESEARCH & DEVELOPLMENT



- 30 COMPANIES
- OVER 100 TASKS

Figure 1-6. On-Going IR&D Efforts

with a dollar value of 10 to 20 million dollars per year. Only a fraction of these dollars are spent on embedded testing support technology. Embedded testing support requires development of "off-the-shelf" technology, which is ready to apply at the early stages of weapon systems design, as a rigorous design discipline.

1.5.2 Applying Testing Technology Early In The Weapon System Acquisition Cycle

Historically, prime system designers have generally regarded maintenance (including testing) and logistic support as an after-design concept. In addition, prime contractors do not adequately and properly communicate to subcontractors the scope and depth of testability required. Neither is there an adequate acceptance test program to evaluate the degree of subcontractor testability conformance. As a result, the Services have been playing catch-up while many of their weapon systems are down. Testing technology must be an integral part of weapon system design. As depicted in Figure 1-7, this technology is closely tied to computer-aided design, logistic support analysis and the automation of diagnostics, test and maintenance. Without this "front-end" attention, investments in testing technology can provide only marginal returns in readiness and cost reduction.

1.5.3 Transiticning Testing Technology

Traditionally, transitioning technology in any field has been difficult. Transitioning technology from basic research to exploratory development to advanced development and to engineering development causes problems, because often each of these RDT&E categories is managed by a separate organizational entity. For the same reason, it has proved difficult to transition testing technology to weapon system design.

1.5.4 Utilizing Industry IR&D

Industry's IR&D investment in testing technology is significant. OSD and the Services have emphasized the need for additional IR&D in each one of the logistic support elements. Without better incentives, improved coordination, and follow-on visibility, much of this industry effort remains unused.

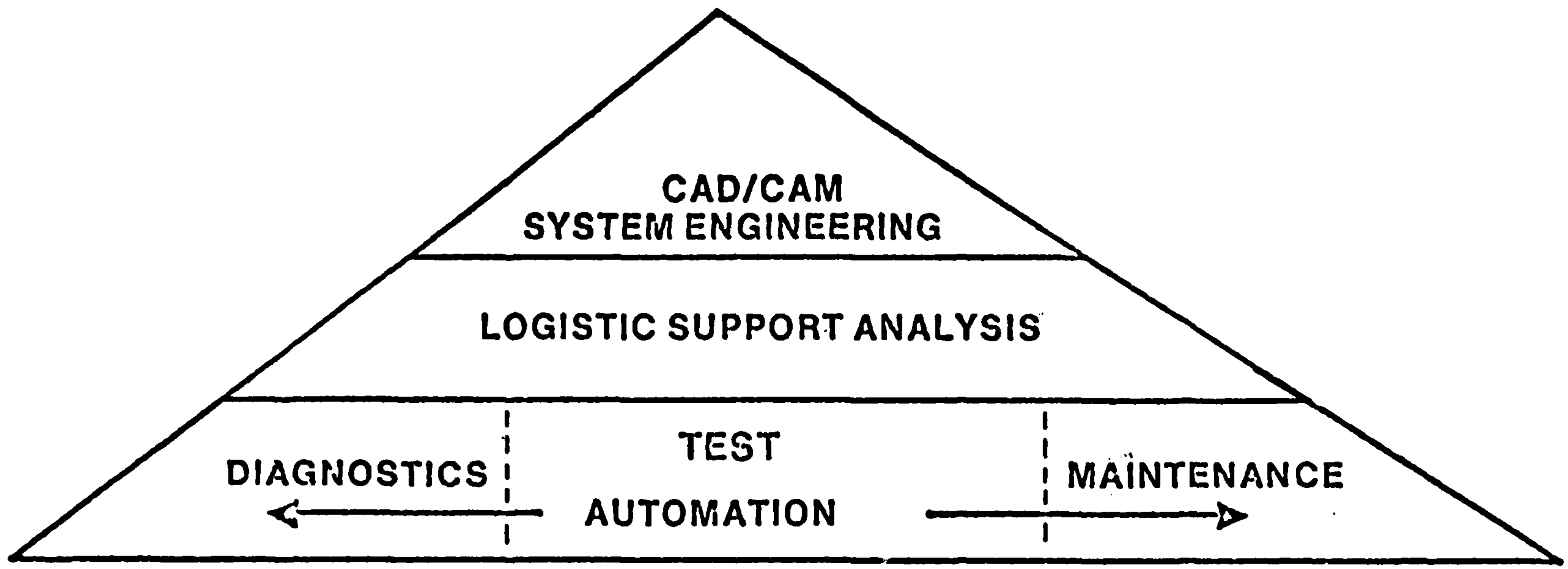


Figure 1-7. Test Technology in Relation to Weapon System Design

SECTION 2. STUDY GOAL AND OBJECTIVES

The objectives of this Testing Technology Study are to:

- Identify the required technology development.
- Estimate the impacts of thest technology developments.
- Identify the key management actions required to support the development and application of this technology.
- Prepare the detailed analysis necessary to justify and defend the priorities that must be afforded this technology and the expected payoffs.

SECTION 3. DEFINING THE REQUIREMENT

Over the past few years the Services and industry have taken a number of significant steps toward defining the requirements for testing technology.

The Navy's program was established as a result of a study directed by the Assistant Secretary of the Navy for Research and Development 1976. This study was culminated in a "Report On Navy Issues Concerning Automatic Test, Monitoring, And Diagnostic Systems And Equipment". This Report identified 20 basic Fleet problems in automatic testing and proposed 14 solutions. The Navy's Testing Technology Program today is based on the findings of this study.

Two or three years later, the Air Force initiated the Modular ATE (MATE) Program. This was a major concept definition program in competition between Sperry and Westinghouse. One of the outputs of this conceptual effort was a set of MATE guides dealing with virtually every aspect of automatic testing and testability. These guides are being used by the Air Force in the acquisition of their automatic testing hardware and software.

The Army has just concluded, within the past year, a DATAT[1] study, which resulted in 22 findings which addressed all aspects of test, measurement, and diagnostic equipment. This study has formed the basis for the Army's technological and managerial approach to solving testing problems.

In 1981 the Assistant Secretary of Defense, Manpower, Reserve Affairs and Logistics sponsored a Built-In-Test Equipment Requirements Workshop. This Workshop was held for the purpose of assessing progress and problems in specifying and evaluating built-in-test used in complex electronic equipment. A number of significant recommendations resulted from this Workshop. These recommendations are documented in the Institute for Defense Analysis Paper, P-1600. Fourteen of these recommendations dealt with specifying and evaluating diagnostics, including built-in-test. Another set of recommendations were made, which clearly identified the need for technology development in built-in-test and diagnostic techniques. This study formed the basis for a DOD-wide program to improve built-in-test and diagnostics.

---

1 Department of the Army Test, Measurement and Diagnostic Equipment Action Team.

Defining and coordinating testing technology effort among the Services is being accomplished through the framework of the Joint Logistics Commanders (JLC). The JLC Panel On Automatic Testing was formed in 1978 and coordinates and guides the Joint Services Automatic Testing program. One of the useful testing technology assessments was developed under this Joint Service Automatic Testing program. It assesses future testing technology needs[2]. This report evaluates the impact of new technologies on testing technology requirements. It also determines the applicability of these new technologies to solving test problems. The report covers new technology in systems, components, electromagnetic transmissions, computers, electro-optics, and acoustics.

Testability, as a defined discipline, has been in being for the last five or six years. However, the institutionalization of testability, including the ability to invoke testability requirements in our weapon systems designs to assure that requirements are met, is in its infancy. Through a Built-In-Test/Testability Improvement Program, initiated under the Joint Service program, the path for institutionalizing testability through a series of standardization documents, which are closely tied to the logistics support analysis process, has been defined. In addition, R&D has been recommended to develop, modify, and evaluate a series of testability analytical tools to aid designers in performing testability trade-offs.

On the other hand, industry has played an important part in defining the Services' testing technology program. Two comprehensive studies have been supported by five industry associations: The Aerospace Industries Association; The Electronic Industries Association; The National Security Industrial Association; The Shipbuilders Council Of America; and, The American Electronics Association. The first of these studies culminated in a "Report Of Industry Ad Hoc Automatic Test Equipment Project For The Navy". This study was directed almost totally at defining RDT&E needs

---

2 NOSC TD 426, Technology Assessment, 1980, Forecast Of Future Test Technology Requirements (March, 1981).

in testing technology and the institutionalization of their use. The following areas were addressed:

Software
Automatic Test Generation
Design For Testability
Propulsion, Electrical, and Auxiliary Systems Monitoring
New Technology
Education, Training, and Management
Advanced ATE Concepts
Operational Readiness Monitoring.

A similar type project for the Joint Services was subsequently undertaken by these five industrial organizations. The Final Report of this "Industry/ Joint Services Automatic Test Project" addressed the following 11 areas:

1. Organizations, People, and Funding
2. Military Equipment Testability
3. Specifications, Directives, Controls, and Deliverables
4. Non-Electronic Test Development
5. Test Program Set Development and Management
6. Automatic Test Technology Development
7. Data Banks and Models For Life Cycle Costing, Logistics Support Analysis, and Technology Assessment
8. System-Software Development and Maintenance
9. Metrology and Calibration
10. Training
11. Maintenance Shop Productivity.

Because of the close working relationship between the Services and industry during this period, the Services' testing technology programs are totally compatible with the industry recommendations.

SECTION 4. TESTING TECHNOLOGY REQUIREMENTS

Investing in testing technology does little good if the Services do not provide a means for weapon system designers to easily use this technology. Figure 4-1 indicates a three-pronged approach to this problem. It includes: 1) development of the technology itself, coupled with; 2) the tools used to apply this technology in the weapon system acquisition process; and, 3) appropriate management attention to ensure proper utilization. Each of these three items is addressed in this Section.

4.1 TESTING TECHNOLOGY

Figure 4-2 depicts a composition of required testing technology. This structure includes the need for weapon system testability design techniques. All of these revolve around the concept of a test bed supported with advanced development funds to evaluate combinations of testing technologies, while being able to ascertain the synergistic effects of each. This test bed concept may also be utilized in relation to the other reliability and maintainability technologies.

The detailed structure of the Program is as follows:

A. Weapon System Testability Design Techniques

- (1) CAD/$\overline{T}$ Design Tools
- (2) LSA Process
- (3) $\overline{T}$ Prediction & Demonstration
- (4) BIT/MTE/ATE/FOMS
- (5) Fault-Tolerant Design

B. On-Line Testing

- (1) Performance Monitoring
- (2) Built-In-Test
- (3) Maintenance Aids
- (4) Non-Electronic Monitoring

C. Off-Line Testing

- (1) ATE
- (2) Applications Software
- (3) Automatic Test Program Generation (ATPG)
- (4) Metrology/Calibration

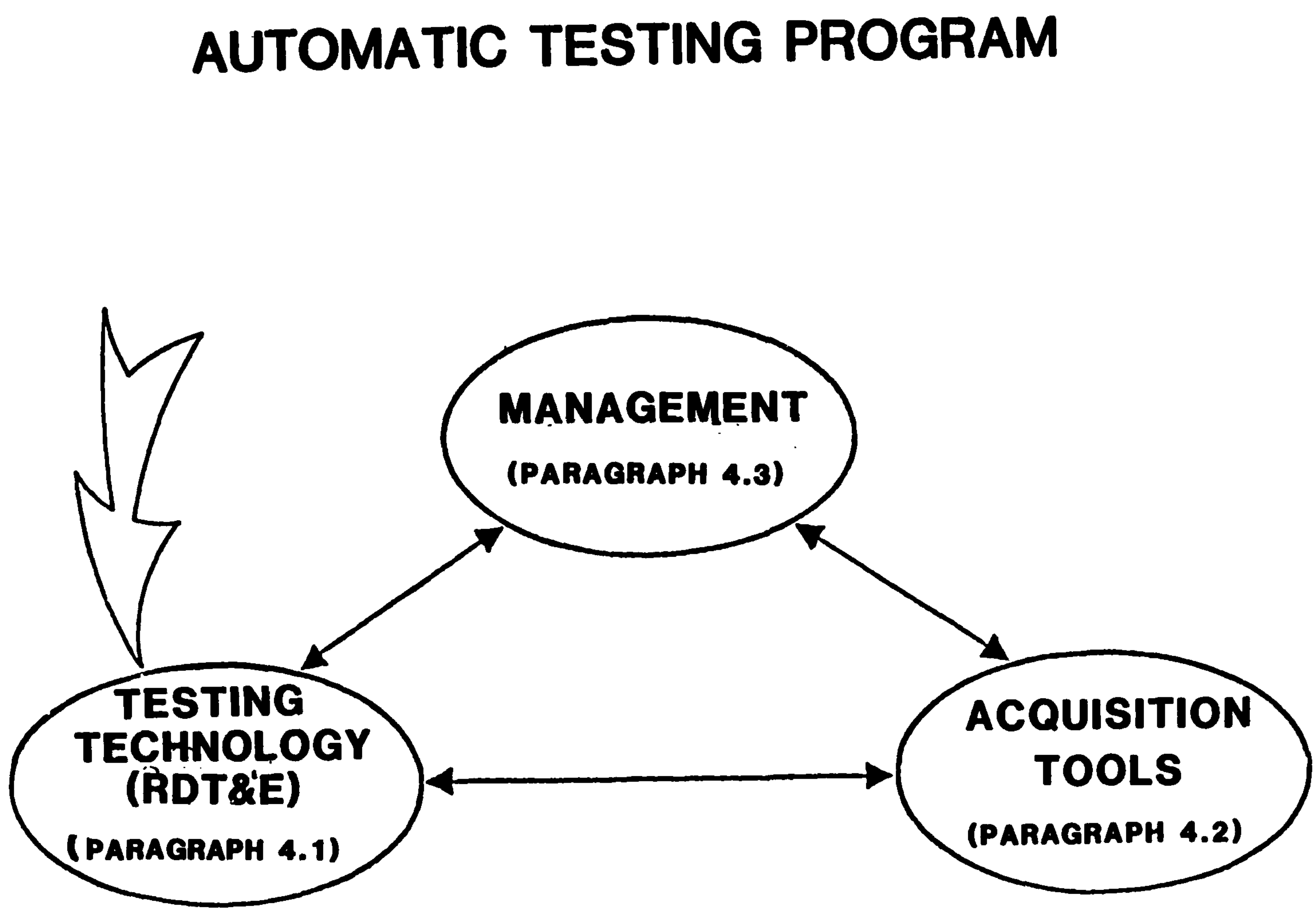


Figure 4-1. Automatic Testing Program

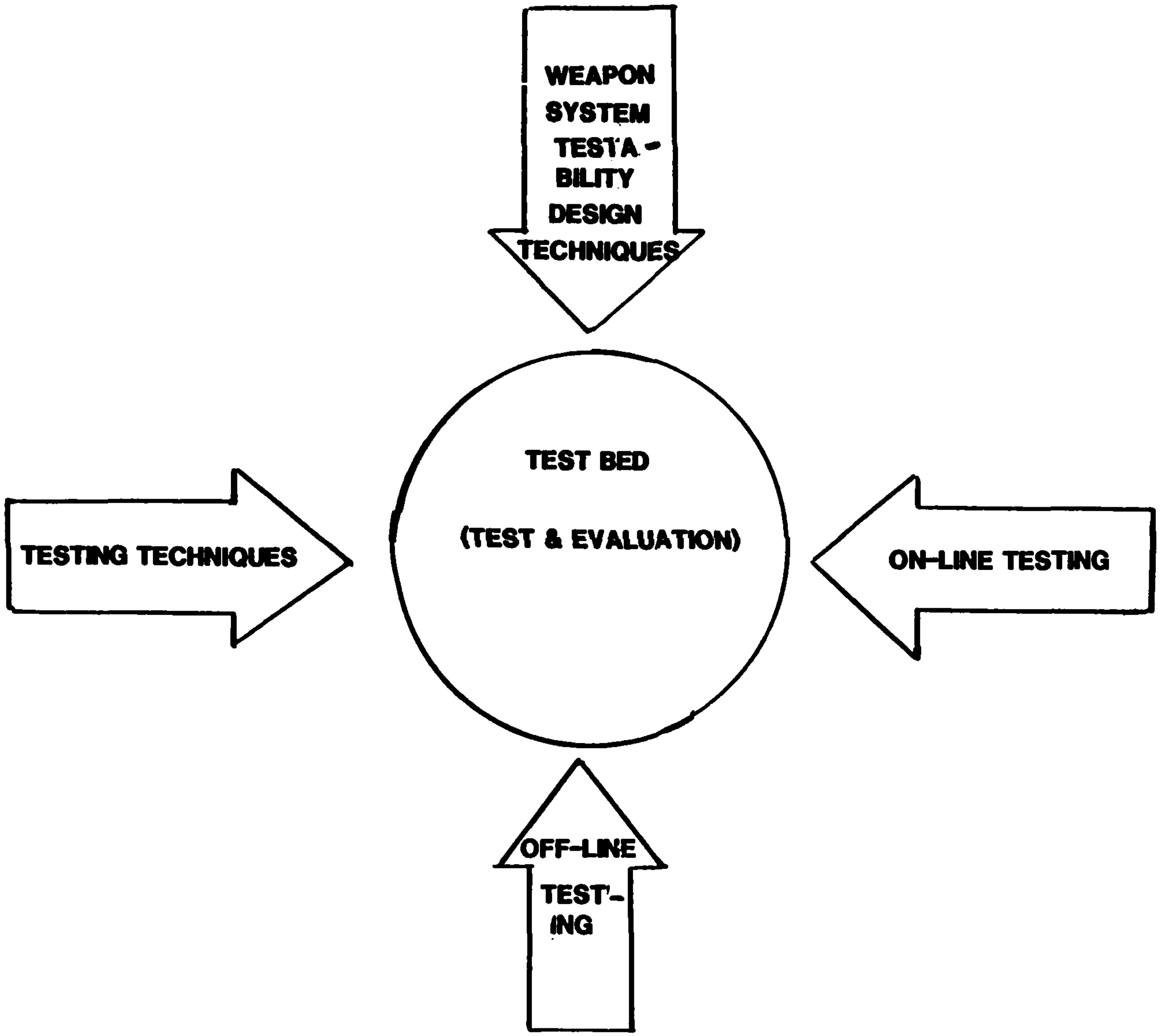


Figure 4-2. Testing Technology Program Structure

D. Test Techniques

(1) Diagnostics/Prognostics

(2) Advanced Device Testing

(3) Non-Conventional Testing

(4) System-Level Testing

E. Test and Evaluation

(1) Test Bed Demonstrations

(2) Experimental Demonstrations.

The approach to defining the required testing technology effort is to:

a. Describe what is required in each part and subpart (Description)

b. Determine on-going and completed work which addresses this requirement (Status), and

c. Identify what additionally needs to be done (Requirement).

Table 4-1 was prepared as a basis for making these judgments. The Table summarizes planned, on-going, and recently completed work in each part of the Program.

4.1.1 Weapon System Testability Design Techniques

Testability is defined as a design characteristic which allows the status (operable, inoperable, or degraded) of a unit (system, subsystem, module, or component) to be confidently determined in a timely fashion. Testability is inherently a weapon system design issue. At present, the use of computerized tools in the design of a weapon system is not an integrated process. The design of the weapon system itself is part of the computer-aided design (CAD) process. Logistics support analysis (LSA) for ILS should support this CAD process, with testability as a major driver. However, testability as a rigorous design technique is in its infancy. Means for specifying, predicting, and demonstrating weapon system testability are not mature.

Table 4-1. Summary Of Testing Technology Tasks

WEAPON SYSTEM TESTABILITY DESIGN TECHNIQUES

LEVEL	DESCRIPTION	COMPLETION DATE	SPONSOR	PERFORMING ACTIVITY	REFERENCES P.E.	REFERENCES PROJ #	NAVY PLAN	JLC PLAN
	COMPUTER AIDED/TESTABILITY DESIGN							
SYSTEM/SUBSYSTEM	CAD DIGITAL SYSTEMS (PARTITIONING, FAULT TOLERANCE, OPTIMIZATION)	9/82	ARMY RESEARCH OFFICE	SOUTHERN CAL. UNIV.	61102A	1L161102EH57		
	CAD FOR ELECTRONICS (NO SPECIFIC T̄ CONSIDERATIONS) (SYSTEM THRU DEVICES)	9/82	AFWAL	AFWAL	62204F	6096		
	CAD DESIGN ANALYSIS (TEST POINT LOC., TOLERANCE, TEST CIRCUITRY)	12/82	RADC	BOEING CO.	62702F	2338		
	CAD/T̄ INTEGRATION	9/85	NAVELEX	NSWC				
MODULE/PCB	DIGITAL PCB DESIGN TRADE-OFF PROCEDURES TO ENHANCE T̄	1/79	RADC	GRUMMAN AEROSPACE	62702F	2338		
DEVICE	CAD FOR HYBRID & MONOLITHIC MICRO CIRCUITS (PARTITIONING, T̄, CONNECTIVITY)	7/82	CECOM	RCA	62705A	1L162705AH94		
	T̄ of VLSI	7/82	RADC	NYU	61101F	LDFP		
	INTEGRATED DESIGN OF LARGE SCALE CIRCUITS (FAULT ANALYSIS, TOLERANCE)	9/81	ONR	UNIV. OF ILLINOIS	61153N	RR0210501	X	
	VHSIC T̄ MONITORING	9/85	NAVELEX	UNIV. OF	62704F		X	30307
	MICROELECTRONICS DESIGN	6/82	ARMY RESEARCH OFFICE	NORTH CAROLINA A&T UNIV.	61102A	1L161102BH47		
	LSA PROCESS							
MISSION RELATED	AVAILABILITY/OPERATIONAL READINESS/TESTABILITY TRADE-OFFS (DIAGNOSTIC, T.E., BIT)	5/80	RADC	LOCKHEED AIRCRAFT	62702F	2338		
LOGISTIC RELATED	T̄ TRADE-OFFS (T̄, COST, DIAGNOSTIC, TESTING)		RADC	OKLAHOMA UNIVERSITY	62702F	2338		

Table 4-1. Summary Of Testing Technology Tasks (Continued)

Weapon System Testability Design Techniques (Continued)

LEVEL	DESCRIPTION	COMPLETION DATE	SPONSOR	PERFORMING ACTIVITY	REFERENCES P.E.	REFERENCES PROJ. #	NAVY PLAN	JLC TASK
LOGISTIC RELATED (Continued)	CAUSES OF UNNECESSARY REMOVAL	10/80	RADC	HUGHES AIRCRAFT	62702F	2338		
	DIAGNOSTIC EQUIPMENT REPAIR		A:ADCOM		OHA			
			TESTABILITY PREDICTION & DEMONSTRATION					
SYSTEM/SUBSYSTEM	$\overline{T}$ DESIGN & EVALUATION	11/82	RADC	BOEING CO.	62702F	2338		
	$\overline{T}$ FOMS	9/83	NAVELEX	NSWC	62762N	XF54856001	X	30303
	$\overline{T}$ FOMS (SUMMARY OF TECHNIQUES)	5/81	NSWC	MANTECH				
	$\overline{T}$ ANALYSIS AS AN INPUT TO ATG	Planned	NSWC	GRUMMAN AEROSPACE				
MODULE/PCB								
DEVICE	$\overline{T}$ OF LSI	3/81	RADC	LEHIGH, UNIVERSITY	61101F	LD94		30203
			BIT/ATE FIGURES OF MERIT					
MAINTAINABILITY/ RELIABILITY	PREDICTION & ANALYSIS (TIES BIT/ATE EFFECTIVENESS TO $\overline{M}$)	7/78	RADC	HUGHES AIRCRAFT	62702F	2338		
	BIT & EXTERNAL TESTER RELIABILITY CHARACTERISTICS	5/80	RADC	LOCKHEED CAL.	62702F	2338		
	BIT & EXTERNAL TESTER FOMS & DEMONSTRATION TECHNIQUES	12/79	RADC	HUGHES AIRCRAFT	62702F	2338		
	FMEA METHODOLOGY	9/80	RADC	KETRON	62702F	2338		
OPTIMIZATION	DESIGN GUIDELINES & OPTIMIZATION PROCEDURES FOR BIT	5/79	RADC	GRUMMAN AEROSPACE	62702F	2338		

Table 4-1. Summary Of Testing Technology Tasks (Continued)

Weapon System Testability Design Techniques (Continued)

LEVEL	DESCRIPTION	COMPLETION DATE	SPONSOR	PERFORMING ACTIVITY	REFERENCES P.E.	REFERENCES PROJ. #	NAVY PLAN	JLC TASK
				FAULT-TOLERANT DESIGN				
SYSTEM/SUBSYSTEM	COMPUTER FAULT-TOLERANT DESIGN (SURVIVABLE COMPUTER)	1/80	AFWAL	SRI	62204F	2003		
	FAULT-TOLERANT DESIGN (RELIABILITY, TESTABILITY, PERFORMANCE MONITORING)	12/83	RADC	SOHAR, INC.	62702F	2338		30301
	CONCURRENT SELF-DIAGNOSTIC AND RECONFIGURATION	3/82	ONR	UNIV. OF ILLINOIS	61153N	RR021-05-01	X	
	COMPLEXITY, TESTABILITY & FAULT ANALYSIS FOR LARGE SYSTEMS	9/83	ONR	UNIV. OF TENNESSEE	61153N	RR021-05-01	X	
	COMPUTER DESIGN USING VLSI	9/85	NAVELEX	NOSC	62762N		X	
DEVICE	VLSI DESIGN (SUBCIRCUIT DUPLICATION, COST EFFECTIVENESS)	7/81	A.F. OFFICE OF SCIEN-TIFIC RES.	TENNESSEE STATE UNIV.	62204F	2003		
	LSI DESIGN ($\overline{T}$ 95-100%)	7/79	AFWAL	IBM	62204F	6096		30301
	FAULT-TOLERANT I.C.	3/83	NOSC	NOSC	62712N	7F12102	X	30504
	MICROWAVE I.C.	9/85	AFSC	ASD				

Table 4-1. Summary Of Testing Technology Tasks (Continued)

ON-LINE TESTING

LEVEL	DESCRIPTION	COMPLETION DATE	SPONSOR	PERFORMING ACTIVITY	REFERENCES P.E.	REFERENCES PROJ. #	NAVY PLAN	JLC TASK
			PERFORMANCE MONITORING					
PLATFORM	SHIPBOARD AUTO. FAILURE DETECTION AND PERFORMANCE MONITORING	12/85	NAVSEA	NOSC	62762N	SF62586	X	
	SHIPS ATE PROGRAM		NAVSEA	NOSC	63712N	S0375-SL	X	
			BUILT-IN-TEST					
SYSTEM/SUBSYSTEM	BIT FOR MISSILES	9/82	MIRADCOM	SPERRY SUPPORT SERVICES	62303A	1L162303A214		
	PIN ELECTRONICS	9/86	CECOM	GIORDANO/TRW	62746A	1L162746A094	X	30510
	STATISTICAL FAULT MONITORING TECH.	9/81	NAVELEX	RESEARCH TRIANGLE	62762N	XF62586001		
	TEST TECHNOLOGY FOR UNDERWATER SYSTEMS	9/85	NAVSEA	NUSC	62762N	SF62586401	X	
	ANALYSIS OF BIT FALSE ALARM CONDITIONS	COMPL	RADC	HUGHES				
	BIT FOR COMPUTERS	9/85	CECOM	ASD				30305
	TURBINE ENGINE MONITORING	9/84	AFSC					30401
DEVICE	LSI/VLSI BIT	6/82	CECOM					30302
	TESTABILITY OF EMERGING TECHNOLOGIES (VLSI, VHSIC, CCDs)	TBD	NAVAIR	NAEC			X	
			MAINTENANCE AIDS					
AIDS	PEAM		NTEC	TEXAS INSTRU. DETEX				
	DEVELOP FORMAT MODELS FOR LEARNING APPLICATION		CNET	TAEG				
	DEVELOP DAMAGE CONTROL ELECTRONIC DELIVERY		AFHRL	BIOTECHNOLOGY				
	AMIS/EPIC		NPRDC	APPLIED SCIENCE ASSOC.				
	DEVELOP HELMET-TYPE AID		DARPA	HONEYWELL				
	NTIPS		DTNSRDC	HUGHES				
	NOMAD		NAVSEA	HAZELTINE				

On-Line Testing (Continued)

Table 4-1. Summary Of Testing Technology Tasks (Continued)

LEVEL	DESCRIPTION	COMPLETION DATE	SPONSOR	PERFORMING ACTIVITY	REFERENCES P.E.	REFERENCES PROJ. #	NAVY PLAN	JLC TASK
			NON-ELECTRONIC MONITORING					
PROPULSION AND MACHINERY	TURBINE ENGINE MONITORING	9/84	AFSC					
	DIESEL MONITORING	9/85	DARCOM					30401
	ATE FOR TURBINE ENGINES	3/84	AFSC					30402
	VEHICLE TESTING	9/86	DARCOM		64764A			30404
	SMPM		NAVSHIPS	DTNSRDC	63585N	S0359-SL	X	30405
SENSORS	SENSOR DEVELOPMENT	9/85	NAVSEA	DTNSRDC	62543N	SD340SL039	X	30403
	DIGITAL FIBER OPTIC MONITORS	9/84	NAVAIR	NAC	62762N	WF62503N	X	
	DIFFERENTIAL PRESSURE TRANSDUCER DEVELOPMENT	6/80	NAVAIR PROPULSION CENTER	HAMILTON STANDARD	62241N	F410401		

Table 4-1. Summary Of Testing Technology Tasks (Continued)

OFF-LINE TESTING

LEVEL	DESCRIPTION	COMPLETION DATE	SPONSOR	PERFORMING ACTIVITY	REFERENCES P.E.	REFERENCES PROJ. #	NAVY PLAN	JLC TASK
	ATE							
	MISSILE $\overline{T}$ FOR COMPATIBILITY	9/82	MICOM	MICOM	62303A	1L162303A214		
	MICROWAVE ATE	9/83	NAVAIR	NAEC	62241N	F41461	X	30511
	PIN ELECTRONICS	9/84	DARCOM	GAI	62746A	1L162746A09	X	30510
	COMMON OFF-LINE ATE	9/84	AFSC		62			30701
	CSS	9/87	NAVAIR	Competitive	64215N			30705
	MATE	9/84	AFSC	SPERRY	64247F			30706
	ATSS	9/85	DARCOM		63748A			30704
	ATE STANDARD INTERFACE	9/84	NAVELEX	NWSC	62762N	XF62586	X	
	APPLICATIONS SOFTWARE							
	TPS COST ESTIMATING	12/84	AFSC					30101
	DEVELOP SOFTWARE MODULES	9/83	AFSC					30103
	UUT SIMULATOR	9/84	AFSC					30104
	ATLAS SUPPORT	3/82	J.S.	GAI		I		30107
	TPS V&V	12/84	AFSC					30110
	ATLAS COMPILER	9/82	AFSC					30111
	ATPG							
	ANALOG $\overline{ATPG}$	6/86	AFSC					30201
	DIGITAL ATPG	12/82	NAVAIR					30202
	NON-LINEAR FAULT DIAGNOSIS	9/83	ONR	NAVY P.G. SCHOOL	61153N	RR0210501	X	
	NON-LINEAR FAULT ANALYSIS	3/83	ONR	TEXAS TECH.	61153N	RR0210501	X	
	FAULT SIMULATION	9/82	ONR	UNIV. OF ILLINOIS	61153N	RR0210501	X	
	METROLOGY/CALIBRATION							
	LASER FREQUENCY STANDARD	9/82	RADC	MIT	61102F	2305		
	STORED ION SPECTROSCOPY FREQUENCY STANDARD	Cont.	ONR	NBS	61153N	RR01103		
	ATE CALIBRATION	9/84	AFSC	NBS				30702
	GSE CALIBRATION		NAVAIR	NAEC/MEC	63		X	
	MECCA			MEC	63		X	
	PICOSECOND PULSE MEASUREMENT	12/85	NAVAIR	NBS/MEC	62		X	
	BEAM UNIFORMITY MEASUREMENTS FOR LASER SYSTEMS	12/85	NAVAIR	NBS/MEC	62		X	

Table 4-1. Summary Of Testing Technology Tasks (Continued)

Off-Line Testing (Continued)

LEVEL	DESCRIPTION	COMPLETION DATE	SPONSOR	PERFORMING ACTIVITY	REFERENCES P.E.	REFERENCES PROJ. #	NAVY PLAN	JLC TASK
	METROLOGY/CALIBRATION							
	DEVELOPMENT OF SYSTEM CALIBRATION TECHNIQUES	12/85	NAVELEX	NOSC	62762N		X	
	STANDARDS FOR MILLIMETER WAVE SYSTEMS	9/85	NAVAIR	NBS, MEC	62		X	
	DEVELOPMENT OF ATE DESIGN FOR CALIBRATION GUIDELINES	9/83	All SYSCOMS	MEC	62		X	
	STANDARDS FOR SUPPORT OF DIGITAL SYSTEMS	9/85	All SYSCOMS	MEC/NBS	62		X	
	JOSEPHSON-EFFECT VOLTAGE STANDARD OPTICAL SCATTERING METROLOGY	9/84	All SYSCOMS	MEC/NBS	62		X	

Table 4-1. Summary Of Testing Technology Tasks (Continued)

TEST TECHNIQUES

LEVEL	DESCRIPTION	COMPLETION DATE	SPONSOR	PERFORMING ACTIVITY	REFERENCES P.E.	REFERENCES PROJ. #	NAVY PLAN	JLC TASK
	DIAGNOSTICS/PROGNOSTICS							
	LARGE SYSTEM FAULT ANALYSIS (NON-LINEAR)	3/82	ONR	NOTRE DAME UNIV.	61153N	RR021-05-01	X	
	MACHINERY DIAGNOSTICS	9/85	NAVSEA	DTNSRDC	62543N	S0340SL039	X	30406
	MACHINERY FAILURE PREDICTION MODELS	9/85	NAVSEA	DTNSRDC	62543N	S0340SL039	X	
	MACHINERY FAILURE PROGNOSIS	12/85	NAVSEA	DTNSRDC	62543N	S0340SL039		30407
	TROUBLESHOOTING (SNEAK CKT ANALYSIS)	5/82	AFHRL	BOEING CO.	61101F	ILIR		
	SELF-IMPROVING DIAGNOSTICS	6/85	AFSC		62			30508
	FAULT DIAGNOSIS OF NON-LINEAR CIRCUITRY	9/83	ONR	PURDUE UNIV.	61153N	RR021-05-01	X	
	FAULT DIAGNOSIS OF NON-LINEAR INTERCONNECTED CIRCUITS	6/85	ONR	JOHNS HOPKINS UNIV.	61153N	RR021-05-01	X	
	FAULT LOCATION ALGORITHMS (ANALOG)	9/85	NAVELEX	NOSC	62762N	XF62586001		30513
	ADVANCED DEVICE TESTING							
	MICROWAVE TUBE PROTECTION	6/84	NAVELEX	NOSC	62762N	XF62586		
	HIGH-POWER TUBE MONITORING	9/85	RADC	RADC	61181F	LD90		
	LASER BEAM ALIGNMENT	6/81	RADC	HUGHES AIRCRAFT	62301F	C503		
	VHSIC TESTING		RADC		62			
	LSI TESTING		ERADCOM		62			
	MICROPROCESSING	9/84	DARCOM		62			30502
	FIBER OPTICS	9/82	DARCOM		62			30503
	BUBBLE & MASS MEMORIES	9/84	AFSC		62			
	CCD's	9/84	AFSC					
	LARGE-SCALE SYSTEM TEST	COMPL	ONR	UNIV. OF MINN.	61153	RR021-05-01	X	
	NON-CONVENTIONAL TESTING							
	ADVANCED E/O SYSTEMS (AIRBORNE)	9/84	NAVAIR	NAEC/NWC	62241N	F41461	X	
	LASER MEASUREMENTS	11/82	AF WEAPONS LAB.	AF WEAPONS LAB.	63000F	0001		
	LASER MEASUREMENTS	9/83	AF WEAPONS LAB.	AF WEAPONS LAB.	62601F	3326		
	ADVANCED OPTICS	12/82	TECOM	TECOM	61101A	1T061101A91A		
	ELECTRONIC BEAM CIRCUIT TESTING		RADC		62			
	NEAR-FIELD ANTENNA MEASUREMENT	12/82	NAVAIR	NAEC	62241N			30512

Table 4-1. Summary Of Testing Technology Tasks (Continued)

Test Techniques (Continued)

LEVEL	DESCRIPTION	COMPLETION DATE	SPONSOR	PERFORMING ACTIVITY	REFERENCES P.E.	REFERENCES PROJ. #	NAVY PLAN	JLC TASK
	SYSTEM LEVEL TESTING							
	COMMUNICATIONS SYSTEM READINESS	12/85	NAVELEX	NOSC	62762N	XF62586	X	

- 2 -

Table 4-1. Summary Of Testing Technology Tasks (Continued)

TEST BEDS

LEVEL	DESCRIPTION	COMPLETION DATE	SPONSOR	PERFORMING ACTIVITY	REFERENCES P.E.	REFERENCES PROJ. #	NAVY PLAN	JLC TASK
LASERS/OPTICS	LASER/OPTICS SUPPORT	Cont.	AF WEAPONS LAB.	ROCKWELL, INT'L DYNALECTRON CORPORATION	63605F	3173		
ANTENNAS	IMPEDANCE & RADIATION PATTERN	Cont.	ERADCOM (Harry Diamond Ctr.)	ROCKWELL, INT'L DYNALECTRON CORPORATION	61102A	1L161102AH44		

The reliability of deployed weapon systems has not proved satisfactory. Traditional reliability approaches are expensive, time consuming, and not altogether satisfactory. Fault-tolerant design techniques mainly have centered around restructuring at the equipment level, which is costly and creates a greater maintenance workload. Present effort in development of fault-tolerant design techniques is fractionated with little thought on "institutionalizing" its use.

4.1.1.1 Computer-Aided Design/Testability Design Tools

Description

During the past few years, the use of computerized tools to design a weapon system has become commonplace. Testability considerations must be injected into these computer-aided design techniques to achieve supportable systems. In the device area, testability must be a major consideration in the design of complex integrated circuits.

Status

At least ten tasks, aimed at injecting testability into the CAD process at the system, module, and device level, have been undertaken. A classic example of how this can be accomplished is in the VHSIC Program. Recognizing that these complex devices could never be successfully tested unless they are designed to be testable, several million dollars have been spent in developing testable design.

Requirement

The ability to inject testability into computer-aided design has not been institutionalized. A major effort is required to interface testability with computer-aided design techniques. The output should be a CAD/LSA/testability interface guide. In the device area, additional funds should be injected into the VHSIC Program to provide for dynamic testing and improved fault coverage.

4.1.1.2 LSA Process

Description

Testability considerations must be injected into the weapon system LSA process as a means for addressing external trade-offs with other logistic elements and concepts during weapon system design.

Status

All three Services are addressing this problem. The Navy has just completed a report on the first phase of their Built-In-Test/Testability Improvement Program. This study analyzes the LSA process, identifies methods for specifying and evaluating BIT/testability, identifies a number of useful testability analysis tools and techniques, and arrives at a recommended document structure to institutionalize the application of BIT and testability. Effort in fiscal year 1983 entails the initiation of a testability analysis handbook and the modification of a number of currently available guides, standards, and policy documents. Rome Air Development Center has sponsored a number of mission-related and logistics-related trade-off techniques. The Army is working on an LSA techniques guide. Testability must be injected into this guide.

Requirement

Although much is being done by the Services to inject testability considerations into the LSA process, much more is required. This remains a difficult job, because the LSA process itself is not structured in such a way to permit straightforward trade-offs among various logistic elements. Maintenance strategies must be reviewed to assure that test and repair are done properly and effectively. The Navy's project to develop a testability analysis handbook for making a variety of types of LSA/testability trade-offs is underway, but is underfunded with very little effort in the development of these type analytical tools. As indicated in a GAO report[3], measures of effectiveness must be developed to provide weapon system designers a method for evaluating the injection of testability alternatives into their system design.

4.1.1.3 Testability Prediction and Demonstration

Description

Methods for predicting and demonstrating how testable a system, unit or device is, are required so that testability can be invoked in procurement specifications.

3 GAO Report (MASAD-82-38) of August 6, 1982.

Status

Much has been done by the Services to develop Testability Figures Of Merit ($\overline{T}$ FOMS) in order that testability can be predicted and evaluated. A survey on the "Application Of Testability Figures Of Merit To The Electronic System Acquisition Process" was completed by the Navy in May, 1981. This study identified and described a number of available means for calculating $\overline{T}$ FOMS, but concluded that the best of these $\overline{T}$ FOMS should be evaluated against actual designs of units before proceeding with further development.

Requirement

Before embarking on the program to further develop $\overline{T}$ FOMS, a hardware evaluation program should be initiated so that the effectiveness of the various methods can be evaluated and further developmental work identified. A testability analysis handbook is required to give weapon system designers instruction on the use of prediction tools. MIL STD 471 requires a revision as a means for demonstrating testability in contractual terms. Measures of effectiveness for various $\overline{T}$ alternatives must be developed, so that weapon system designers have a means for predicting $\overline{T}$ payoffs.

4.1.1.4 BIT/MTE/ATE/FOMS

Description

BIT/MTE/ATE/FOMS are needed to make a variety of trade-offs involving the type BIT, manual test equipment (MTE), and ATE best suited for a specific job; trade-offs between BIT, MTE, and ATE to arrive at the optimum combination; and, injection of these FOMS into the maintainability and reliability prediction and analysis process.

Status

RADC has sponsored the development of a number of trade-off tools in this area.

Requirement

A means must be developed for injecting these Figures Of Merit into the LSA process in the weapon system design process. Revision of MIL STD 1513 is required.

4.1.1.5 Fault-Tolerant Design

Description

Fault-tolerant design includes a combination of redundancy, system reconfiguration, and performance monitoring to achieve both weapon system reliability and maintainability goals.

Status

Much effort has been sponsored in development of a number of system, subsystem, and device fault-tolerant design techniques mostly in the basic research and exploratory development areas. NOSC has defined a Fault-Tolerant Design Program, aimed at a combination of redundancy, performance monitoring, and system reconfiguration.

Requirement

A major Fault-Tolerant Design Program is required, which includes a combination of redundancy, system reconfiguration, and performance monitoring to achieve reliability and maintainability goals. The application of these techniques needs to be institutionalized by preparing a fault-tolerant design guide.

4.1.2 On-Line Testing

On-line testing is defined as testing a weapon system or unit in its operational environment. It includes built-in-test, built-in-test equipment, performance monitoring, status monitoring, maintenance aiding, etc. Whether on-line testing is at the ship level, the aircraft level, the vehicle level or the weapon system level, it involves "designing-in" a comprehensive testing hardware and software capability during the acquisition process.

4.1.2.1 Performance Monitoring

Description

Performance monitoring is aimed at automatically ascertaining the "health" of a weapon system and the environmental conditions that a weapon system and the people who operate and maintain it "see". The data gathered is more command/operation oriented, as opposed to maintenance. Aboard ship, it would supplant much of the manual data recording and reporting now used, thus improving the communication of combat readiness information to

all affected command and maintenance stations, and reduce the possibility of maintenance-induced failures while performing planned maintenance. For aircraft, recording of in-flight data can be used for subsequent diagnostic and prognostic purposes.

Status

A major program for development of a shipboard Operational Readiness Monitoring capability transitioned from exploratory development and was, subsequently, cancelled by Congressional budget action. A demonstration test bed was developed and the feasibility and worth of the concept proven.

Requirement

The project should be revitalized and proceed through advanced development, so that requirement can be included in ship developmental specifications. Revision of MIL STD 1326 is required to control interfaces with weapon systems.

4.1.2.2 Built-In-Test (BIT)

Description

Built-in-test is integral to the design of the platform, vehicle, system, subsystem, or device requiring testing. BIT at the system and subsystem level fault detects and fault isolates down to a given ambiguity group. BIT at the device level provides for the ready testing of the device to ascertain its operating condition.

Status

The Air Force Test and Evaluation Center conducted a comprehensive analysis on the effectiveness of BIT on three major aircraft. A major program to improve the effectiveness of BIT has been undertaken by the Navy, with a Fleet survey of BIT effectiveness for two dozen deployed weapon systems. Two BIT workshops have been conducted. All of these actions have helped define needed improvements in BIT. A major policy and documentation review is presently underway, so that BIT application is properly institutionalized.

Requirement

RDT&E is required to provide off-the-shelf technology for weapon system projects. This includes:

a. Development of "Pin Electronics" concepts for BIT

b. Development of "smart BIT" using artificial intelligence and knowledge-based systems

c. Further development of BIT for VHSIC devices.

4.1.2.3 Maintenance Aids

Description

Maintenance aids, sometimes referred to as job performance aids, provide diagnostic and procedural information to assist technicians in maintaining weapon systems. It is possible to embed much of this capability into the weapon system design and thus enhance the on-line testing capability.

Status

A major survey of maintenance aids was conducted in FY82. Significant R&D has and is being sponsored to develop maintenance aids, including:

a. PEAM Program - Development of devices for the dual purpose of maintenance aiding and on-the-job training.

b. EPIC Program - Development of maintenance aids as a means for providing relatively untrained technicians with valuable assistance, thus delaying formal technician training until individual capability and motivation can be evaluated and re-enlistment intentions are known.

c. NTIPS - A major 6.3 program designed to provide electronic delivery of operational, maintenance, and logistic information to the Fleet. Maintenance aiding is one facet of the program.

All these programs are presently in their evaluation phase.

Requirement

a. Development of LCC models to determine the degree of application of maintenance aids.

b. Determination of the appropriate mix of BIT, ATE, and maintenance aids.

c. Institutionalizing their application.

d. Development of the BIT/ATE guided-probe concept.

e. Standardization of hardware and software.

4.1.2.4 Non-Electronic Monitoring

Description

RDT&E for the testing and monitoring of non-electronic weapon system and equipment (e.g., propulsion, electrical, auxiliary machinery) is required.

Status

a. Automatic test systems to analyze performance and operation of diesel and gas turbine engines have been developed and put into operation by the Navy test community. These test systems have increased the operational availability by reducing maintenance-related documents of the prime systems using these engines.

b. The National Bureau of Standards has prepared a handbook describing available sensors and application information for non-electronic monitoring.

c. High-accuracy differential pressure transducers to sense the fan discharge mach number for aircraft gas turbine engines have been developed.

Requirement

a. Development of a shipboard machinery performance monitoring system.

b. Development of a BIT/testability non-electronic design guide.

4.1.3 Off-Line Testing

Off-line testing is accomplished by a combination of automatic and manual test equipment, coupled with the necessary software for test program sets required to diagnose faulty units. Development of manual test equipment required by the Services is being accomplished by industry, using IR&D funds. Except in special cases, the Services do not and should not invest their dollars to develop manual test equipment. On the other hand, automatic test equipment, to a large degree, is designed to the operational and support requirements of the Services. Logistic support (including calibration) is required for all types of test equipment.

4.1.3.1 Automatic Test Equipment (ATE)

Description

ATE is required to provide for timely testing of units removed from a weapon system for repair.

Status

Each Service is in the process of developing advanced, mission-oriented ATE. The Navy is in the final phases of conceptual development of the Consolidated Support System (CSS). This project addresses total repair shop throughput (i.e., ATE for multiple-weapon support, the shop management system, the shop environment, and its logistic support). The Air Force's Modular ATE (MATE) Program is presently being implemented. It standardizes the ATE acquisition process and the system architecture (e.g., IEEE Std. 488 bus, MIL STD 1750 computer architecture, IEEE Std. 716 ATLAS). The Army's Automatic Test Support System (ATSS) development is just underway. It is aimed at forward-level deployment of ATE.

Requirement

Both Navy and Army ATE programs are investing in Pin Electronics as the next generation ATE. In essence, this is the concept of "ATE on a chip", which eliminates the complex switching problem of present-day ATE by placing a testing capability at each pin of a UUT. In addition, more effort is required as a means for addressing units employing VHSIC devices.

4.1.3.2 Applications Software (TPS)

Description

This covers techniques for developing test program sets (TPS's), including test programs, interface devices, and associated documentation.

Status

a. Standardization of a test language was accomplished by working with industry and ultimately sponsoring IEEE to control and monitor the ATLAS test language.

b. A standard military subset of ATLAS (IEEE Std. 716) was produced to simplify the use of this standard language.

c. Techniques and guidelines were developed for TPS configuration management and for validation and verification methods. Experience has shown that uncontrolled development of test program sets for ATE can be very costly.

d. A TPS Acquisition Guide was developed for project managers use.

e. A Test Program Design Guide was developed for use by designers of test programs.

Requirement

TPS cost estimating techniques must be validated as a means for controlling their acquisition costs.

4.1.3.3 Automatic Test Program Generation (ATPG)

Description

This covers techniques for computer-aided methods for generating analog, digital, and hybrid test programs.

Status

a. Digital ATPG techniques have been developed and refined to significantly reduce costs of test programming.

b. A "Selection Guide For Digital Test Program Generation Systems" (NAVMATP 9493, CARCOMP 70-9, AFLC 800-41, AFSC 800-41, NAVMC 2718) 1981 was produced, which described 29 available ATPG's.

Requirement

ATPG for units employing VHSIC-type devices must be developed. Because of the complexity, standard techniques are unacceptable for use.

4.1.3.4 Metrology/Calibration

Description

This covers metrology and calibration methods and standards for all types of test equipment.

Status

A number of standards and equipments have been developed. One of the major developments has been MECCA, which is an automatic calibration system. Hundreds of these systems have been deployed at both shore and shipboard calibration labs, at a substantial reduction in cost and manpower.

Requirement

a. Development of standards are required, such as:

   - Microwave Standards 18-45 GHz
   - High RF Power Standards
   - Electrical Voltage Standards
   - IFF/TACAN/VOR Standards
   - Multimeter Standards
   - Instrument Micro-Controllers.

b. Techniques for calibrating ATE at its terminals, in lieu of calibrating each box (module) separately, are required.

4.1.4 Test Techniques

The extensive, and sometimes unnecessary, maintenance actions on weapon systems place high demands on personnel and test equipment, and adversely affect combat readiness. Furthermore, the employment of new and emerging technologies, which offer opportunities for reducing manning requirements for future weapon system operation; will impose increased demands on maintenance personnel.

4.1.4.1 Diagnostics/Prognostics

Description

Diagnostic and prognostic techniques are needed in both the electronic and non-electronic areas in order to meet a planned requirement for planned 100 percent fault detection and fault isolation.

Status

For electronics, a large number of diagnostic techniques have been developed ranging from computerized automatic test generation techniques to the use of maintenance dependency charting techniques. There is little diagnostic consistency during weapon system design, beginning with FMEA and progressing through test requirement documentation requirements, BIT design, ATE test program generation, maintenance manuals, and maintenance training. Limited guidance exists on a variety of diagnostic approaches available.

Research has been performed in the area of simulation and modeling to aid in fault analysis, fault prediction, TPS automated production, and in the design of testable digital architectures.

Requirements

a. Development of methods for specifying diagnostic parameters, which are mission driven.

b. Development of trade-off procedures/man-machine allocation procedures to provide the best mix of diagnostic hardware and software for a given application.

c. Review and revision of applicable standards, specifications and guides to institutionalize Integrated Diagnostics.

d. Development of Integrated Diagnostics data base and feedback systems.

e. Development of Integrated Diagnostics application handbook.

f. Development of diagnostics and prognostics techniques for non-electronic applications.

g. Development of a non-electronic testability guide.

4.1.4.2 Advanced Device Testing and Non-Conventional Testing

Description

This covers a variety of testing techniques for testing advanced devices or using these advanced devices for non-conventional testing applications.

Status

A substantial number of tasks have been supported by the Services dealing with the testing of lasers, optics, antenna measurements, fiber optics, high-power tubes, etc. Examples are:

a. Investigation of 12 areas for improving the capability of E/O airborne devices.

b. Measurements and calibration methods for laser weapon systems.

c. Methods for analysis of unique interference tests for advanced optical systems.

Requirement

A number of tasks under the JLC Automatic Testing Program remain unfunded. These are in the MIS 305 series and deal with the testing of memories, charge-coupled devices, E/O devices, etc.

4.1.4.3 System-Level Testing

Description

This covers system-level testing (e.g., communications, E.W.) and is usually characterized by end-to-end tests for system checkout.

Status

Some communications system-level test techniques have been developed.

Requirement

An opportunity exists to combine operational training and system-level testing for the ships combat and damage control systems. This capability can be embedded in the weapon system. Radars, fire control systems, sonars, etc., can be stimulated using distributed microprocessors, allowing checkout of each system based on real-life operational scenarios. On-the-job operator training can be performed as an adjust capability. PMS checks, system checkout, system alignment, trend analysis, etc., all appear feasible.

4.1.5 Test And Evaluation (Test Beds)

Description

None of the technology development discussed in the above paragraphs can be developed in a vacuum. Scientific test beds, including prototypes, need to be utilized for use in evaluating various testing technology improvements in an integrated, realistic operating environment.

Status

Although a number of test beds have been constructed and used, none has across-the-board application.

Requirement

Scientific test beds, including prototypes, need to be developed and made available for use in evaluating various testing technology improvements in an integrated, realistic operating environment. The main thrust of the development effort should focus on emerging testing technology advances in performance monitoring, built-in-test, fault detection, fault diagnostics, self test, automated calibration, self calibration, fault-tolerant design, data buses, and all other technological improvements which must be evaluated prior to their inclusion in either the weapon system design or an ATE application. The importance of a test bed is the ability to measure the synergistic effects of these various advances in technology, such as:

a. The operation of built-in-test with redundant systems.

b. The compatibility of built-in-test with off-line testers.

c. The extent of built-in-test required with fault-tolerant design.

d. The prediction and measurement of testability as a design parameter.

e. A demonstration of the applicability and worth of advances in technology to a potential user (e.g., project manager, field).

f. The compatibility of system-level testing and operator training.

g. The worth of operational readiness monitoring in today's field environment.

Summarizing what is required:

a. Development and operation of a test bed(s).

b. Experimentally applying this testing technology to weapon systems, including comprehensive tracking to ascertain the worth of these concepts.

4.2 ACQUISITION TOOLS

Applying the output of testing technology requires the institutionalization of acquisition tools. These include:

a. Preparation of design and application guides, standards and specifications for weapon system designers.

b. Establishment and maintenance of informational data banks for use with analytical models.

c. Development and offering of educational courses for project managers and weapon system designers in the application of testing technology.

Table 4-2 summarizes mandatory and non-mandatory documents and educational courses, which are required to accomplish institutionalization and application of testing technology in relation to the program developmental requirements. The status of each is indicated. Much effort is required to prepare or modify these documents.

4.3 MANAGEMENT

Transitioning test technology to weapon system design requires a number of management initiatives.

a. An organizational entity is required within each Service and OSD to plan, coordinate and transition testing technology through to weapon system design.

b. Policy directives are required for each Service to establish such an organization and to assure technology developments are funded and pursued.

c. Controls over development of testing technology and its application are required.

d. Methods for Joint Service coordination of testing technology is required.

TABLE 4-2. TITUTIONALIZING TEST TECHNOLOGY

DOCUMENT \ DEVELOPMENT	Weapon System $\overline{T}$ Design Techniques					On-Line Testing				Off-Line Testing				Test Techniques			
	CAD/$\overline{T}$ Design Techniques	LSA Process	$\overline{T}$ Prediction & Demonstration	BIT/ATE/MTE FOMS	Fault-Tolerant Design	Performance Monitoring	Built-In-Test	Maintenance Aids	Non-Electronic Monitoring	ATE	Applications Software	Automatic Test Program Generation	Metrology/ Calibration	Diagnostics/ Prognostics	Advanced Device Testing	Non-Conventional Testing	System-Level Testing
JLC GUIDES																	
* Acquisition	M	M	M	M	M	M	M	M	M	M	M	S	M	M			
* Acquisition Review		M	M	M	M	M	M	M	M	M	M	S	M	M			
* BIT Design				M	M	M	M	M					M	M			M
* Digital Test Prog. Gen.												M					
$\overline{T}$ Design	I		I		I		I	I					I		I	I	
Non-Electronic $\overline{T}$ Design	P		P		P		P	P	P				P		P	P	
* Sensors							M		M				M				
Non-Elex BIT Desigr				P	P	P	P	P	P				P				P
TPS Acquisition			I								I						
Test Program Design											I						
* Information Systems	M	M	M	M													
$\overline{T}$ Analysis	I	I	I	I	I		I	I						I			
OTHER GUIDES																	
* LSA Techniques	M	M	M	M										M			
Fault-Tolerant Design	P		P		P	P			P					P			
CAD/LSA/$\overline{T}$ Interface	P	P	P	P	P			P						P			
Diagnostics/Prognostics	P		P				P	P				P		P			
* ATLAS Users (IEEE)											M						
Performance Monitoring						P			P								
EDUCATIONAL COURSES																	
* A.T. Acquisition	M	M	M	M	M	M	M	M	M	S	S	M	M				
* Design for $\overline{T}$	M	M	M	M	M	M	M	M	M	S	S	M	M	M			M
ATLAS (716)										P							

Legend:
P - Proposed
S - Satisfactory
M - Modification Required
I - In Preparation
* - Existing

NON-MANDATORY

TACLE 4-2. INSTITUTIC .IZING TEST TECHNOLOGY (Continued)

DOCUMENT / DEVELOPMENT	Weapon System $\overline{T}$ Design Techniques: CAD/$\overline{T}$ Design Techniques	LSA Process	$\overline{T}$ Prediction & Demonstration	BIT/ATE/MTE FOMS	Fault-Tolerant Design	On-Line Testing: Performance Monitoring	Built-In-Test	Maintenance Aids	Non-Electronic Monitoring	Off-Line Testing: ATE	Applications Software	Automatic Test Program Generation	Metrology/ Calibration	Test Techniques: Diagnostics/ Prognostics	Advanced Device Testing	Non-Conventional Testing	System-Level Testing
MANDATORY																	
LSA																	
* MIL STD 1388	M	M	M											M			
RMA																	
* MIL STD 470A $\overline{M}$			M				M							M			
* MIL STD 785B $\overline{R}$							M							M			
* MIL STD 454G Gen. Req.							M										
TESTING																	
MIL STD (XXX) $\overline{T}$			I				I	I						S			
* MIL STD 471A Demo.			M		M		M	M		S	M		M	M			
* MIL STD 2077 TPS											M						
* MIL STD 2076 ATE/UUT Compatibility																	
* MIL STD 1345/1519 TRD											M			M			
* IEEE 416/716 ATLAS											S						
* MIL STD 1309 Definitions			I										M	M			
* MIL STD 1513 ATE Selection		M		M						M							
* MIL STD 1326						M											

Legend:
P - Proposed
S - Satisfactory
M - Modification Required
I - In Preparation
* Existing

4.4 PROGRAM SUMMARY

Table 4-1 summarizes recently completed, on-going, and planned technology development. It is a reasonably complete picture of the program. Over 100 tasks have been identified, and an equal number of IR&D efforts is estimated. Figure 4-3 is a list of 25 known sponsors and Figure 4-4 lists 51 known performing activities drawn from Table 4-1. Figure 4-5 is a list of 27 Program Elements, which support this effort.

4.4.1 Program Funding

Table 4-3 summarizes Testing Technology requirements and status, and estimates the available and required funding ranges. The basic research and exploratory development funded effort estimates are reasonably accurate, because they are characterized by almost level-funding. Advanced and engineering development funding varies sharply year-by-year, and thus, what is shown is a "snapshot". Figure 4-6 is a funding summary, which indicates that basic research and exploratory development is funded at \$7M annually - 50 percent of requirements. Advanced and engineering developments are funded at \$27M - 77 percent of requirements. This does not include a substantial deficit in the CSS out-year funding.

4.4.2 Program Priorities

Figure 4-7 prioritizes the various parts of the Testing Technology Program based on test issues; the affect on weapon system operational readiness, life cycle cost and manpower considerations; technical risk; and the size of the funding deficiency. High priorities are given to:

- Weapon system design, using testability/BIT/fault tolerance/performance monitoring techniques, incorporated into the CAD/LSA process.
- Diagnostic/prognostic techniques, integrating FMEA, BIT/Testability maintenance aiding, ATPG into a cohesive, institutionalized process.
- Non-electronic test and monitoring techniques.
- System-level test techniques.

S P O N S O R S

AFHRL	MICOM
AFOSR	MIRADCOM
AFSC	NAVAIR
AFWAL	NAVELEX
ARADCPM	NAVSEA
ARO	NOSC
CECOM	NPC
CNET	NPRDC
DARCOM	NSWC
DARPA	NUSC
DTNSRDL	ONR
ERADCOM	RADC
	TECOM

Figure 4-3. Sponsors Of Testing Technology

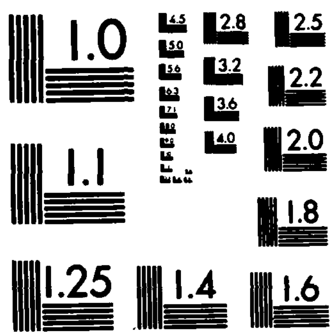
AD-A137 526 TESTING TECHNOLOGY WORKING GROUP REPORT (IDA/OSD R&M (INSTITUTE FOR DEFEN..(U) INSTITUTE FOR DEFENSE ANALYSES ALEXANDRIA VA SCIENCE AND TECH.. G W NEUMANN 2/2

UNCLASSIFIED AUG 83 IDA-D-41 IDA/HQ-83-25924 F/G 15/3 NL

END

FILMED

DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

PERFORMING ACTIVITIES

AFWAL	KETRON	NWSC
ASD	LEHIGH UNIV.	NYU
BIOTECHNOLOGY	LOCKHEED	OKLA. UNIV.
BOEING	MANTECH	PURDUE UNIV.
DETEX	MEC	PRD
DTNSR&DL	MIT	RADC
GD-E	MINN. UNIV.	RCA
GE	NAC	RESEARCH TRIANGLE
GIORDANO ASSOC.	NAEC	SOHAR
GRUMMAN	NBS	SOUTHERN CAL.
HAMILTON STD.	NCA&T	SPERRY
HAZELTINE	NOSC	SRI
HONEYWELL	NOTRE DAME	TENN. STATE
HUGHES	NPGS	TENN. UNIV.
IBM	NSWL	TEXAS TECH.
ILL. UNIV.	NUSC	TI
JHU	NWC	TRW

Figure 4-4. Performing Activities

PROGRAM ELEMENTS

BASIC RESEARCH	EXPLORATORY DEVELOPMENT	ADVANCED ENGINEERING DEVELOPMENT
61101F	62204F	63000F
61102A	62241N	63585N
61102F	62301F	63712N
61153N	62303A	63727
61181F	62543N	63733
	62601F	63748A
	62702F	64215N
	62705A	64247F
	62712N	64709N
	62746A	64722A
	62762N	64746A

Figure 4-5. Testing Technology Program Elements

TABLE 4-3. SUMMARY OF TESTING TECHNOLOGY REQUIREMENTS AND STATUS

WEAPON SYSTEM TESTABILITY DESIGN TECHNIQUES

F - FUNDED
R - REQUIRED

REQUIREMENTS	STATUS	ANNUAL FUNDING RANGE			
		0-200K	200-500K	500-1000K	>1000K
CAD/$\bar{T}$ DESIGN TECHNIQUES	FUNDED 1. MANY SMALL PIECEMEAL TASKS AT SYSTEM, MODULE AND DEVICE LEVEL (6.1 & 6.2) REQUIRED 1. 6.3 PROGRAM - INTEGRATE CAD/$\bar{T}$ 2. CAD/LSA/$\bar{T}$ INTERFACE GUIDE		F	R	
LSA PROCESS	FUNDED 1. A FEW LIMITED TASKS (MISSION AND LOGISTIC RELATED) REQUIRED 1. A VARIETY OF LSA TRADE-OFF TOOLS, INTEGRATING $\bar{T}$ WITH OTHER ILS ELEMENTS, CAPABLE OF TAILORING 2. 6.3 PROGRAM FOR VALIDATION 3. REVISION OF LSA TECHNIQUES HANDBOOK 4. REVISION OF MIL STD 1388	F	R		

TABLE 4-3. SUMMARY OF TESTING TECHNOLOGY REQUIREMENTS AND STATUS (CONTINUED)

WEAPON SYSTEM TESTABILITY DESIGN TECHNIQUES (CONT'D)

REQUIREMENTS	STATUS	ANNUAL FUNDING RANGE			
		0-200K	200-500K	500-1000K	>1000K
T PRED. & DEMO.	FUNDED 1. A NUMBER OF METHODS FOR DETERMINING FIGURES OF MERIT 2. T STANDARD REQUIRED 1. EVALUATION OF AVAILABLE TFOMS ON HARDWARE PROTOTYPES 2. MEASURES OF EFFECTIVENESS FOR T ALTERNATIVES 3. T ANALYSIS HANDBOOK 4. REVISION OF MIL STD 471		F	R	
BIT/ATE/MTE FOMS	FUNDED 1. SEVERAL TECHNIQUES FOR PREDICTION AND OPTIMIZATION REQUIRED 1. REVISION OF MIL STD 1513	F/R			

TABLE 4-3. SUMMARY OF TESTING TECHNOLOGY REQUIREMENTS AND STATUS (CONTINUED)

WEAPON SYSTEM TESTABILITY DESIGN TECHNIQUES (CONT'D)

REQUIREMENTS	STATUS	ANNUAL FUNDING RANGE			
		0-200K	200-500K	500-1000K	>1000K
FAULT TOLERANT DESIGN	FUNDED 1. MANY TASKS FUNDED REQUIRED 1. 6.3 PROGRAM TO SYNTHESIZE AND VALIDATE TECHNIQUES 2. DEVELOPMENT OF DESIGN TECHNIQUES USING A COMBINATION OF REDUNDANCY, PERFORMANCE MONITORING, AND SYSTEM RECONFIGURATION 3. FAULT TOLERANT DESIGN GUIDE		F	R	

TABLE 4-3. SUMMARY OF TESTING TECHNOLOGY REQUIREMENTS AND STATUS (CONTINUED)

ON-LINE TESTING

REQUIREMENTS	STATUS	ANNUAL FUNDING RANGE			
		0-200K	200-500K	500-1000K	>1000K
PERFORMANCE MONITORING	FUNDED 1. ONE 6.2 MONITORING TASK REQUIRED 1. 6.3 PROGRAM - OPERATIONAL READINESS MONITORING 2. IN-FLIGHT MONITORING TECHNIQUES 3. REVISION OF MIL STD 1326	F			R

TABLE 4-3. SUMMARY OF TESTING TECHNOLOGY REQUIREMENTS AND STATUS (CONTINUED)

ON-LINE TESTING (CONT'D)

REQUIREMENTS	STATUS	ANNUAL FUNDING RANGE			
		0-200K	200-500K	500-1000K	>1000K
BIT	FUNDED 1. LIMITED SUPPORT TO DEFINE BIT DEFICIENCIES 2. SOME EFFORT ON VHSIC TESTING REQUIRED 1. MAJOR EFFORT REQUIRED TO ADAPT "PIN ELECTRONICS" CONCEPT FOR BIT 2. MORE EFFORT ON BIT/$\overline{T}$ FOR VHSIC 3. EFFORT REQUIRED TO DEVELOP "SMART" BIT 4. INSTITUTIONALIZATION OF BIT/$\overline{T}$ REQUIRED THROUGH DEVELOPMENT AND REVISION OF SERIES OF STANDARDS, GUIDES AND HANDBOOKS (SEE JLC $\overline{T}$/BIT IMPROVEMENT PROGRAM)	F		R	

TABLE 4-3. SUMMARY OF TESTING TECHNOLOGY REQUIREMENTS AND STATUS (CONTINUED)

ON-LINE TESTING (CONT'D)

REQUIREMENTS	STATUS	ANNUAL FUNDING RANGE			
		0-200K	200-500K	500-1000K	>1000K
MAINTENANCE AIDS	FUNDED 1. SIGNIFICANT NUMBER OF DEVELOPMENTAL AND EVALUATION EFFORTS REQUIRED 1. LCC MODELS TO DETERMINE DEGREE OF APPLICATION 2. DETERMINE INTERFACE WITH BIT AND ATE 3. STANDARDIZATION OF HARDWARE AND SOFTWARE 4. GUIDED PROBE SOFTWARE DEVELOPMENT 5. INSTITUTIONALIZATION EFFORT TOTALLY INADEQUATE				F/R

TABLE 4-3. SUMMARY OF TESTING TECHNOLOGY REQUIREMENTS AND STATUS (CONTINUED)

ON-LINE TESTING (CONT'D)

REQUIREMENTS	STATUS	ANNUAL FUNDING RANGE			
		0-200K	200-500K	500-1000K	>1000K
NON-ELECTRONIC MONITORING	FUNDED 1. SENSOR HANDBOOK PUBLISHED 2. FIBER OPTIC AND PRESSURE TRANSDUCER DEVELOPMENT 3. MAJOR EFFORT IN VEHICLE MONITORING REQUIRED 1. MAJOR EFFORT IN SHIPBOARD MACHINERY PERFORMANCE MONITORING 2. BROADER SCOPE SENSOR DEVELOPMENT EFFORT 3. DEVELOPMENT OF BIT/$\overline{T}$ DESIGN GUIDE 4. TURBINE AND DIESEL MONITORING EFFORT				F/R

TABLE 4-3. SUMMARY OF TESTING TECHNOLOGY REQUIREMENTS AND STATUS (CONTINUED)

OFF-LINE TESTING

REQUIREMENTS	STATUS	ANNUAL FUNDING RANGE			
		0-200K	200-500K	500-1000K	>1000K
ATE	FUNDED 1. MAJOR SERVICE DEVELOPMENTAL PROGRAMS (MATE, CSS, ATSS) 2. PIN ELECTRONICS DEVELOPMENT REQUIRED 1. EXPANSION OF PIN ELECTRONICS DEVELOPMENT				F/R
APPLICATIONS SOFTWARE (TPS)	FUNDED 1. DEVELOPMENT OF ATLAS AND ATLAS COMPILER 2. TPS V&V TECHNIQUES 3. TPS ACQUISITION GUIDE 4. DEVELOPMENT OF TPS COST ESTIMATING TECHNIQUES				F/R

TABLE 4-3. SUMMARY OF TESTING TECHNOLOGY REQUIREMENTS AND STATUS (CONTINUED)

OFF-LINE TESTING (CONT'D)

REQUIREMENTS	STATUS	ANNUAL FUNDING RANGE			
		0-200K	200-500K	500-1000K	>1000K
ATPG	FUNDED 1. ANALOG AND DIGITAL ATPG TECHNIQUES 2. 6.1 EFFORT IN FAULT DIAGNOSIS REQUIRED 1. ATPG FOR VHSIC TYPE APPLICATIONS		F	R	
METROLOGY/CALIBRATION	FUNDED 1. SEVERAL TASKS FOR DEVELOPMENT OF STANDARDS AND CALIBRATION TECHNIQUES FOR LASERS, PULSE MEASUREMENTS, MILLIMETER WAVE SYSTEMS, ETC. REQUIRED 1. MAJOR PROGRAM FOR ATE CALIBRATION TECHNIQUES	F		R	

TABLE 4-3. SUMMARY OF TESTING TECHNOLOGY REQUIREMENTS AND STATUS (CONTINUED)

TEST TECHNIQUES

REQUIREMENTS	STATUS	ANNUAL FUNDING RANGE			
		0-200K	200-500K	500-1000K	>1000K
DIAGNOSTICS/PROGNOSTICS	FUNDED 1. MANY LIMITED TASKS REQUIRED 1. DEVELOP A DIAGNOSTIC FLOW DIAGRAM FOR THE WEAPON SYSTEM ACQUISITION CYCLE. INTEGRATE DIAGNOSTIC PROCEDURES INTO THIS PROCESS. 2. DEVELOP DIAGNOSTIC TECHNIQUES GUIDE. 3. DEVELOP PROGNOSTIC PROCEDURES FOR BOTH ELECTRONIC AND NON-ELECTRONIC APPLICATIONS 4. DEVELOP MACHINERY DIAGNOSTIC PROCEDURES		F	R	

TABLE 4-3. SUMMARY OF TESTING TECHNOLOGY REQUIREMENTS AND STATUS (CONTINUED)

TEST TECHNIQUES (CONT'D)

REQUIREMENTS	STATUS	ANNUAL FUNDING RANGE			
		0-200K	200-500K	500-1000K	>1000K
ADVANCED DEVICE TESTING	FUNDED 1. MULTIPLE TASKS FOR TESTING ADVANCED DEVICES (I.E., LASERS, E/O, MICROWAVE TUBES, VHSIC, MICROPROCESSORS, ETC.)				F/R
NON-CONVENTIONAL TESTING	FUNDED 1. SEVERAL TASKS FOR E/O, LASERS, ANTENNA MEASUREMENTS, ETC.			F/R	
SYSTEM LEVEL TESTING	FUNDED 1. COMMUNICATION MONITORING REQUIRED 1. MULTIPLE SYSTEM TYPE TESTING TECHNIQUES REQUIRED	F			R

TABLE 4-3. SUMMARY OF TESTING TECHNOLOGY REQUIREMENTS AND STATUS (CONTINUED)

TEST BEDS

REQUIREMENTS	STATUS	ANNUAL FUNDING RANGE			
		0-200K	200-500K	500-1000K	>1000K
	FUNDED 1. SEVERAL TEST BEDS FOR LASERS, OPTICS, ANTENNA RADIATION PATTERNS, ETC. REQUIRED 1. 6.3 PROGRAM TO INTEGRATE AND EVALUATE TESTING TECHNOLOGY CONCEPTS AND TECHNIQUES (TEST BED CONCEPT) 2. EXPERIMENTALLY APPLY TO FIELDED EQUIPMENTS				F/R

ANNUAL FUNDING SUMMARY ($M)

	PRESENT LEVEL		ANNUAL REQUIREMENT		ANNUAL DEFICIENCY	
	6.1 / 6.2	6.3 / 6.4	6.1 / 6.2	6.3 / 6.4	6.1 / 6.2	6.3 / 6.4
WEAPON SYSTEM T̄ DESIGN	1	0	2	1	1	1
ON-LINE TESTING	1	2	3	6	2	4
OFF-LINE TESTING	2	25	4	25	2	0
TEST TECHNIQUES	3	0	5	1	2	1
TEST BED	N/A	N/A	0	2	0	2
TOTAL	7	27	14	35	7	8

6.1 / 6.2 = 50% OF REQUIREMENTS
6.3 / 6.4 = 77% OF REQUIREMENTS*
* DOES NOT INCLUDE CSS OUT YEAR FUNDING DEFICIENCY

Figure 4-6. Annual Funding Summary ($M)

RELATIVE PRIORITIES

MAJOR -3 HIGH -H MEDIUM-2 MEDIUM-M MINOR -1 LOW -L NONE -0	INHERENT TESTABILITY	TEST EFFECTIVENESS	TEST EFFICIENCY	OPERATIONAL READINESS	LCC	MANPOWER	TOTAL	TECHNICAL RISK	ANNUAL DEGREE OF DEFICIENCY			PRIORITY
									200-500K	500-1000K	>1000K	
WEAPON SYSTEM $\bar{T}$ DESIGN												
CAD/$\bar{T}$ DESIGN	3	3	2	3	3	2	16	H		✓		H
LSA PROCESS	2	3	3	2	3	3	16	H	✓			H
$\bar{T}$ PRED. & DEMO.	3	3	3	2	2	1	14	L	✓			M
BIT/ATE/MTE FOMS	1	2	3	2	2	2	12	M	✓			L
FAULT TOLERANT DESIGN	3	3	3	3	2	2	16	M		✓		H
ON-LINE TESTING												
PERF. MONITORING	1	2	1	3	3	3	13	M			✓	M
BIT	1	3	3	3	3	3	16	M		✓		H
MAINTENANCE AIDS	1	3	3	3	2	3	15	M	✓			M
NON-ELEX MONITORING	2	3	3	3	2	3	16	M			✓	H
OFF-LINE TESTING												
ATE	1	3	3	3	3	2	15	M			✓	M
APPLICATIONS SOFTWARE	0	3	3	3	3	2	14	M	✓			M
ATPG	1	3	3	3	3	2	15	H	✓			M
METROLOGY/CALIBRATION	0	2	3	2	2	2	11	L		✓		L
TEST TECHNIQUES												
DIAGNOSTIC/PROGNOSTICS	2	3	3	3	2	2	15	L		✓		H
ADV. DEVICE TESTING	1	3	2	3	2	2	13	H	✓			L
NON-CONVENTIONAL TESTING	1	3	2	2	3	2	14	H	✓			M
SYSTEM-LEVEL TESTING	1	3	3	3	2	2	14	M			✓	
TEST BEDS	2	3	3	2	3	2	15	N/A			✓	M

4.4.3 The Interface Of Testing Technology With Other Technologies

Testing Technology has a great many interfaces with other R&M technologies. Figure 4-8 is a Venn diagram which illustrates some of these interfaces and reflects quantitatively how much of these technologies are common. The major point is that none of the R&M technologies can adequately solve the readiness problem by themselves, and a correct mix of each is required if the problem is to be solved.

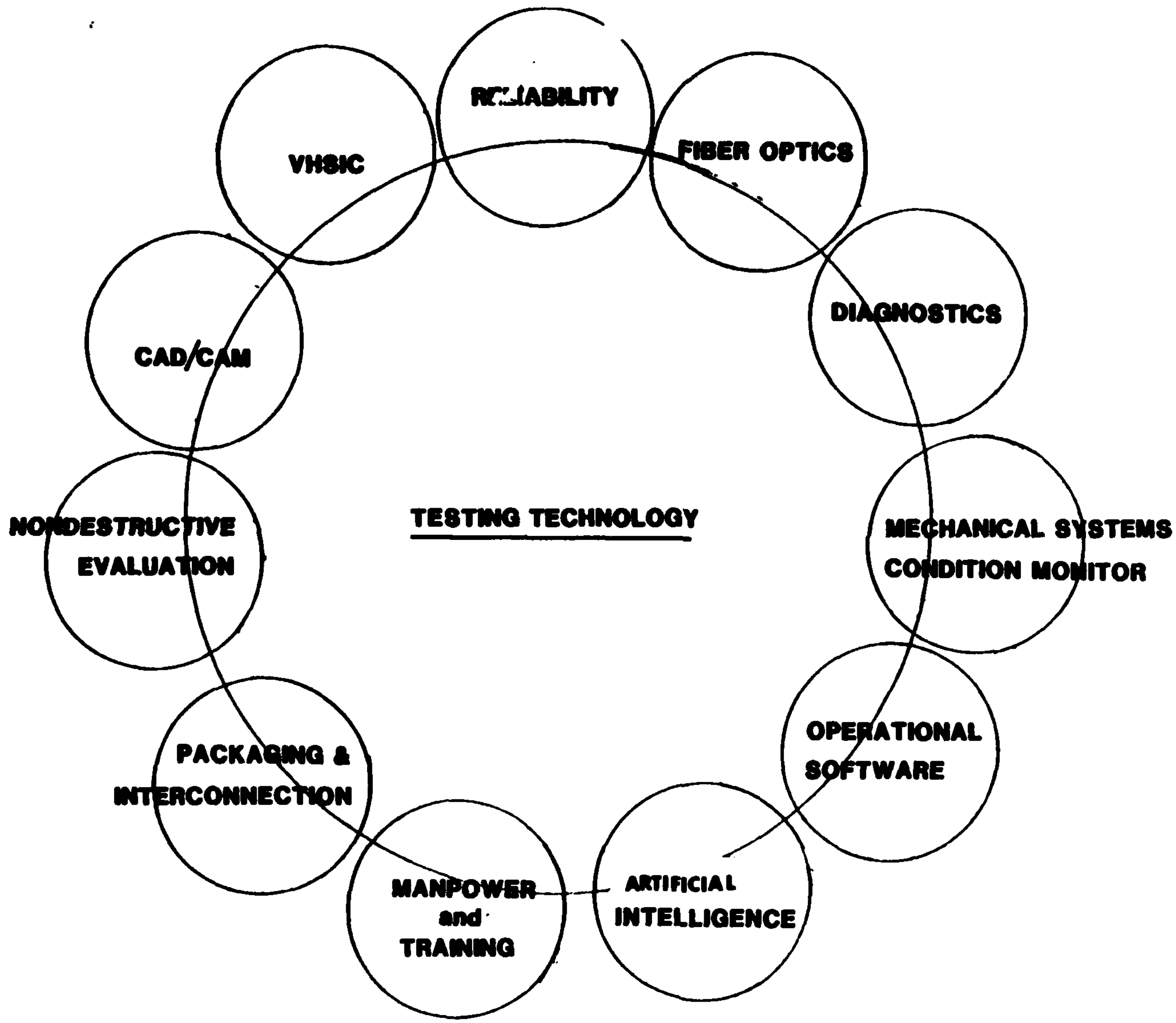


Figure 4-8. Testing Technology Interfaces With Other Technologies

SECTION 5. BENEFITS ANALYSIS AND TECHNOLOGY PAYOFFS OF TESTING TECHNOLOGY

Thus far, this report has detailed the current programs in testing technology and identified the required additional programs. The judgment on what is required, based upon expert opinion, has been documented in major reports published since 1975. Despite this level of credibility, the specific benefits and payoffs of testing technology must be proven.

The measures of effectiveness defined earlier in this report show many specific areas where benefits could be quantitified. In fact, there are several dozen measures of effectiveness which relate testing technology to logistics parameters. These parameters are further related to reliability and maintainability measures which impact system readiness. The problem in benefits analysis is really a problem of selecting among the measures, or stated in other terms, which payback is of most value. Each of the benefits from each of the testing technology research areas must be traded-off against each other. The value of a particular benefit, therefore, becomes subjective and in competition with other benefits.

5.1 COMMON DENOMINATOR IS COST REDUCTION

There is, however, a common denominator in valuing the testing technology trade-offs. Since readiness requires improvements in reliability and maintainability, and since these improvements can be achieved through many different approaches, the only common denominator becomes cost reduction. Therefore, the overriding benefit of testing technology must be measured, not only in its impact on readiness but also on its impact on reducing total ownership cost of a system.

5.2 OPERATIONAL REQUIREMENTS MUST CALL OUT PERFORMANCE VS. TIME

Before trade-off of various approaches can begin, it is imperative that the requirements for logistically driven measures and concepts be in the specifications for new systems. This requirement must be inputted at the earliest levels (Conceptual Phase) of a system life cycle. Operational requirements specified in early documents such as Statement of Need must state the required logistic related time dependencies. If these parameters are not included in the Operational Statement of Requirements, then the

trade-offs are unlikely to be required downstream. Usually project managers consider logistics as a follow-on cost and find that in a near-term budget problem the logistics cost can, and should, be deferred. If these time-related requirements are properly stated up-front as real needs, they can be assured of staying in a program. This report strongly suggests in its conclusion that the performance capability of a system be supplemented with time-dependent measures of performance capability. In this manner, the time dependence will drive the logistics requirements and the project managers will become aware of the importance of logistics on system performance over time. This is referred to in this report as "speaking the language" of the weapon system designer.

5.3 TRADE-OFFS DRIVEN BY COST

Given an operational requirement which drives the logistics side of a system, the benefits trade-offs will be between such items as:

- Mean Time Between Failure
- Mean Time to Repair
- Mean Logistics Delay Time
- Personnel Numbers
- Personnel Skills
  - Training
  - Maintenance Aiding
- Spares/Facilities/Space
- Built-In-Test vs. Off-Line Testing
- Organizational, Intermediate and Depot Level Test Allocations
- Acquisition Cost/Performance Capability
- Mobility
- Environment.

It is apparent that on a life cycle cost basis, one of the key drivers is the acquisition cost of the system. The relative importance of acquisition cost makes the trade-offs extremely complicated. This is because the acquisition costs have been escalating due to increasing system complexity relating to the threat. In addition, the Administration has a major program underway to build up the strength of conventional and

strategic U. S. Forces. The importance of acquisition costs, therefore, cannot be understated. To do so would completely undermine the purpose of this study.

It must be concluded then that the overriding benefit that testing technology must address is cost reduction. Payoffs, which can be measured in total cost reduction, must be prioritized so that they can be used to balance the spiralling acquisition cost in Defense spending.

5.4 PRODUCTIVITY IS KEY TO COST REDUCTION

When viewed in these terms, it becomes very obvious that the key to testing technology benefits analysis can be measured in terms to productivity. Productivity improvement must be a product of technology investment.

5.4.1 Japanese Model

The model usually used to measure productivity is the Japanese model. The Japanese model is based upon a concerted effort to provide a major investment in automation across all Japanese industry. Within the Japanese model, the dollars required for this major investment come from such items as:

a. Inventory Reduction During The Manufacturing Process. This is achieved by very tight scheduling of workflow utilizing automation techniques.

b. Reduced Production Cost Through Quality Improvement. Quality Circles and Quality Programs lead to a much higher yield in production lines than the equivalent U. S. factories.

c. Intensive Value Engineering Programs. Japanese manufacturers are utilizing Value Engineering within their own operations and at all subcontractor and vendor levels. Cost reduction goals are set and Value Engineering programs instituted on a continuing basis to reduce product cost.

d. <u>Encouraged Savings By Employees In Company and Private Savings Accounts</u>. It is not illegal in Japan for companies to utilize employee savings programs as a source of direct investment in automation equipment. This is equivalent to U. S. corporations utilizing pension plans for capital investment, which is illegal in the U. S.

In order to direct the flow of money from the above areas into automation, the Japanese model is driven by deliberate government cooperation with industry. A very broad program of tax incentives encourages the flow of money into automation projects. Japanese workers receive tax benefits for savings. In addition to government support, the Japanese model is driven by an extremely favorable attitude of employees. This attitude is principally the result of the Japanese work culture. Japanese companies have a very paternal attitude toward employees. Employees are not in danger of layoffs during cost cutting operations. In addition, an intense feeling of pride in product and quality is engendered among employees on a continuing basis. These key drivers are contrary to the U. S. culture. Therefore, attempts to duplicate the Japanese model on a one-for-one basis will not work.

5.4.2 Return On Investment Drives U. S. Decisions

The key U. S. productivity improvement, therefore, must be driven by technology without the benefit of an outpouring of dollars, as is the case in the Japanese economy. American investment must be based upon a calculable return on investment, which makes the capital expenditure justifiable on a short-term basis. Short-term is measured in a period of three to five years. An opportunity exists in testing technology to affect such a formula for investment. This opportunity is available because most of the problems, which are impacted by low yield and poor quality, are embodied in the "rework cost" of production defects and "repair costs" of field failures and returns.

In essence, reducing the cost of rework and repair is equivalent to increasing the quality and yield of a product.

5.5 DIAGNOSTICS DRIVES COST REDUCTION

The driver in rework cost and repair cost is not the physical repair actions, but the cost of diagnostics. Diagnostics is the capability of determining what exactly is wrong when a system fails.

Simply stated, diagnostics addresses the following two questions:

Am I OK?

If not, why not?

If testing technology can reduce ambiguity group size in diagnostics, then the basic cost drivers, namely repair, rework, and spares cost, will be cut sharply.

This report addresses overall testing technology improvement with emphasis on weapon system design, on-line testing, and off-line testing. Specific diagnostic improvements are derived from product design, production testing in our factories, and service testing by the military user.

5.6 SPECIFIC BENEFITS AND PAYOFFS

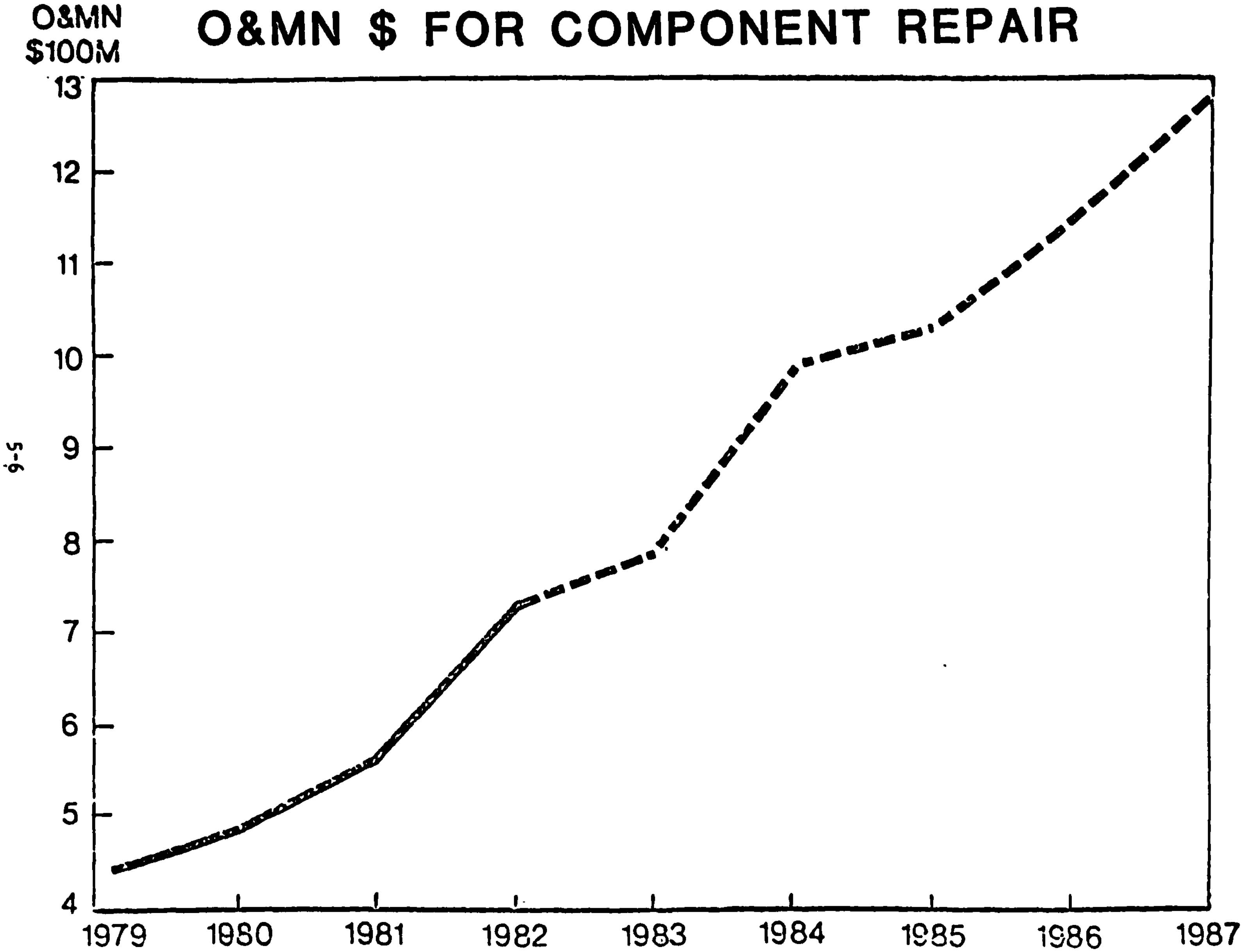
Figure 5-1 graphically depicts the escalating O&MN[4] cost for component repair for Navy aviation. These figures are from studies conducted by the Navy's Aviation Supply Office and communicate a three-fold increase in the cost of component repair over a nine-year period. Figures 5-2 through 5-5 indicate that a small number of systems contribute to the major portion of the maintenance cost. Figure 5-6 indicates that for a rather nominal investment these key items could be made more reliable and maintainable. Improvements in 239 key items on just four aircraft could reduce the total O&MN and aviation component repair cost by 30 percent - a saving of $331.6 million dollars in 1987. Multiplying this figure by the number of years these components are required can amount to many billions of dollars.

O course, there are varieties of methods for obtaining and improving the reliability and maintainability of these components. However, improving the diagnostics and testing for these components is a major cost driver. These figures, although only applicable to four Navy aircraft, have a significant impact on testing technology payoffs in two ways. The first is embedded test support. If these items had been designed to be testable

---

4 Operation and Maintenance (Navy)

O&MN $ FOR COMPONENT REPAIR



* TOTAL ANNUAL O&MN COST PECULIAR TO A-6E/EA-6B APPROXIMATES (FY82) $60.5M
* ELEVEN KEY SYSTEMS (7%) REPRESENT 78% OF COST

NAME	# OF REPAIRABLES	ESTIMATED O&MN COST (M)
* ALQ-99	1088	$13.5 (8 ITEMS; 44%)
* DRS	200	10.6 (3 ITEMS; 28%)
* CSD	3	4.7
* APQ-148/156	101	4.5 (3 ITEMS; 17%)
* ASN-31	27	4.0 (2 ITEMS; 38%)
* WINGS	6	3.2
* ASQ-133/155	61	2.6 (3 ITEMS; 20%)
* USH-17	51	1.4 (3 ITEMS; 45%)
* TAILPIPES	4	1.2
* SDC	3	.9
* AYA-6	93	.6
		$47.2M

Figure 5-2. A-6E/EA-6B Repair Costs

★ TOTAL ANNUAL O&MN COST PECULIAR TO S-3A APPROXIMATES (FY 82) $49.6M

★ ELEVEN KEY SYSTEMS (20%) REPRESENT 74% OF COST

NAME	REPAIRABLES	ESTIMATED O&MN COST
1. RADAR APS-116	92	11.0 (10 ITEMS, 80%)
2. FLIR OR-89	55	5.2 (3 ITEMS, 90%)
3. FLIGHT CONTROL SYSTEM	145	4.7 (8 ITEMS, 80%)
4. ASA-82	87	3.0 (5 ITEMS - 75%)
5. APU	24	3.0 (1 ITEM - 70%)
6. ASA-84 ASN 107	49	2.2 (4 ITEMS, 85%)
7. OL-82 (SANDERS)	240	1.8 (4 ITEMS - 60%)
8. ALR-47	24	1.8 (3 ITEMS, 70%)
9. OL-82 (IBM)	13	1.6 (5 ITEMS 75%)
10. AIRFRAME COMPONENTS	23	1.4 (2 ITEMS 75%)
11. OK-248	48	1.2 (3 ITFMS - 88%)

Figure 5-3. S-3A Repair Costs

* TOTAL ANNUAL O&MN COST PECULIAR TO F-14 APPROXIMATES (FY82) $50M
* THIRTEEN KEY SYSTEMS (44%) REPRESENTS 74% OF COST

NAME	REPAIRABLES	ESTIMATED O&MN COST (M)
* RADAR	519	11.1 (3 ITEMS; 77%)
* INS	80	6.7 (5 ITEMS; 72%)
* CSDC	114	2.2 (2 ITEMS; 86%)
* DISPLAYS	91	1.3 (3 ITEMS; 62%)
* AFCS	15	0.8 (3 ITEMS; 42%)
* ESC/AIS	83	1.3 (6 ITEMS; 52%)
* AWG-15	25	1.1 (3 ITEMS; 56%)
* CSD	5	0.9
* BRAKES	1	6.7
* WING SEALS	2	1.1
* AUX TANKS	1	1.0
* WEAPONS RAIL	1	1.5
* RELEASE MECHANISMS	2	1.3

Figure 5-4. F-14 Repair Costs

TOTAL ANNUAL O&MN COST PECULIAR TO F/A 18 APPROXIMATES (BY FY 84) $115M
TWELVE KEY SYSTEMS (26%) REPRESENT 88% OF O&MN

NAME	REPAIRABLES	ESTIMATED O&MN COST (M)
RADAR	101	16.2 (5 ITEMS, 47%)
MISSION COMPUTER	10	15.3 (1 ITEM, 48%)
FLIR	141	11.0 (1 ITEM, 90%)
FLIGHT CONTROL (AIRFRAME)	28	6.4 EVEN
AMAD	10	6.9 EVEN
ARMAMENT	37	4.7 EVEN
EJECTION SYSTEM	20	3.8 EVEN
FUEL SYSTEM	32	3.6 (3 ITEMS, 60%)
IAS	27	3.7 EVEN
HSD	49	2.6 (1 ITEM, 65%)
DISPLAYS	43	2.4 (3 ITEMS, 30%)
FLIGHT CONTROL ELECTRONICS	69	2.3 (1 ITEM, 43%)

Figure 5-5. FA-18 Repair Costs

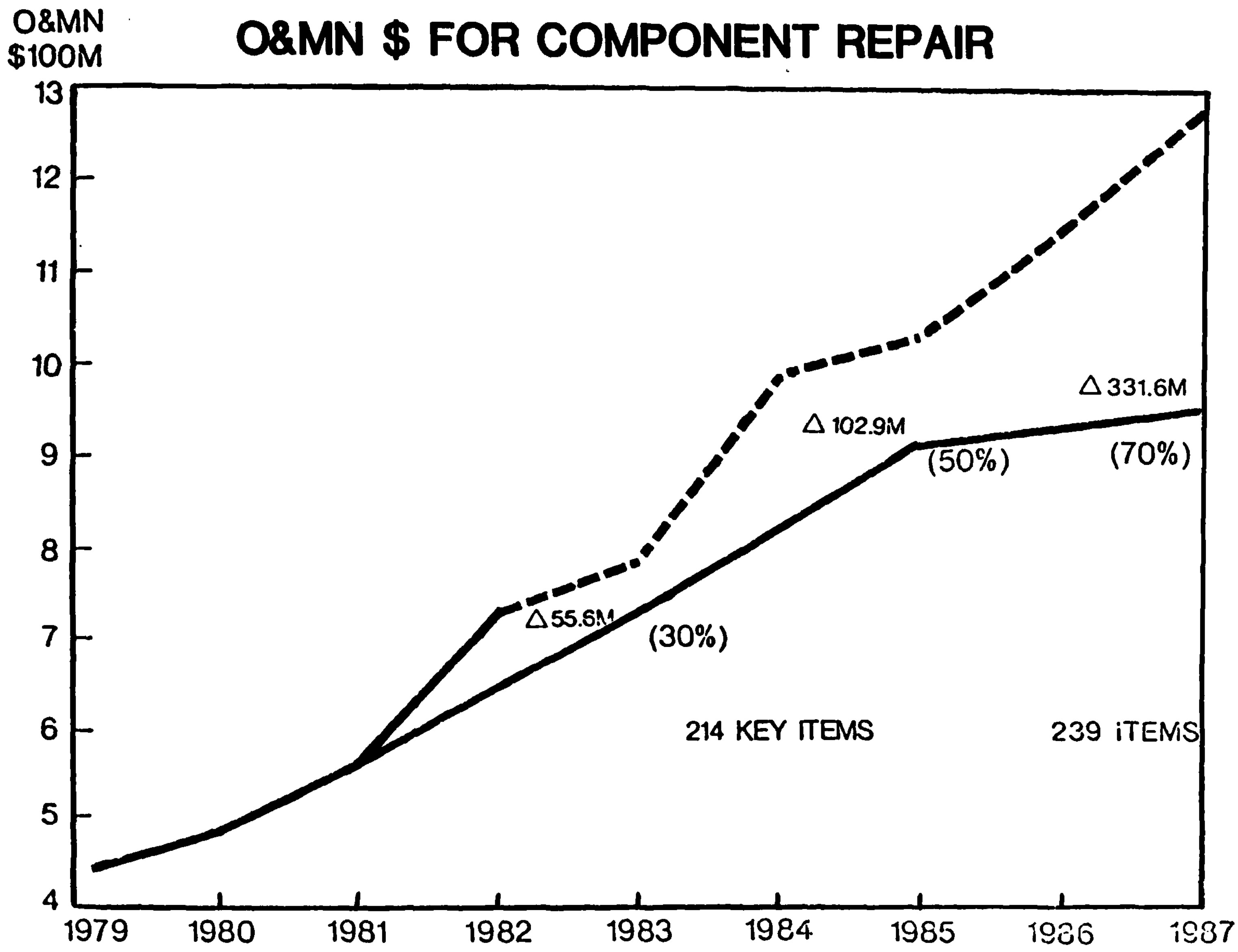


Figure 5-6. O&MN $ For Component Repair

at the time the weapon system was designed, there would be little need for after-the-fact improvements. Secondly, if a diagnostic capability through improved test program sets for existing off-line ATE was added, much the same reduction in cost would occur. The difference in these two approaches is that the second alternative requires significantly more dollars to obtain much the same cost savings. Expanding on this example, the specific benefits and payoffs from embedded test support and off-line testing are projected in the following paragraphs.

5.6.1 Embedded Test Support

5.6.1.1 Maintenance Benefits

Designing-in testability on new weapon systems has the highest potential of all approaches in testing technology research and development. A 10 to 20 percent reduction in life cycle costs can be achieved by employing good testability design.

The principal technological payback from embedded testing is the improvement in system readiness. Readiness is improved by enhancing the capability of the system to pinpoint the areas where problems may exist (diagnostics). On-line testing will help focus for the operator the particular areas that require attention by maintenance crews. Unambiguous monitoring of system performance capability for critical parameters and the measurement of the time dependence of that capability is essential for system operation. By adding embedded testing capability, we enhance both the performance and the support of that system.

The cost of embedded testing capability approximates 10 percent of the total system development cost. This cost includes both design cost and fabrication of the on-line testing hardware and software. Industry estimates show that this cost is recovered prior to delivery in cost savings during factory production testing.

Effectiveness is measured by the ability of the on-line testing system to detect faults to a level which matches the support concept (resource allocation) for that system.

Performance monitoring and diagnostic capability can now be achieved with modern, sophisticated electronics. Also, using new technology, false alarms can be drastically reduced by using microprocessor controlled systems which become intelligent built-in test sensors.

Technology advances, which are directly related to improving the capability for on-line testing and monitoring, include R&D programs such as Universal Pin Electronics. Utilizing advanced semiconductor techniques and devices such as high-speed analog-to-digital and digital-to-analog converters one can develop functional digital, parametric digital, and analog test capabilities within a single measurement channel. This channel can be reduced in size ("ATE on a chip") using hybrid techniques. Availability of this technology to the industry at large will result in the more effective usage of on-line testing. Technological advances in effect can be used to actually reduce operational and maintenance complexity of a system as seen by the user.

Parameters which may be used to express the payoff relate to P_T. P_T is a measure of the time dependence of a performance capability. For example, using this measure one can monitor degraded levels of performance. By monitoring performance levels, systems will not be shut down when small anomalies change the performance characteristics. Without performance monitoring, systems must be shut down since the operator is not aware of what his reduced capability is. Also, by reducing ambiguity group size (exact location of failure) through on-line testing, the performance time dependency on logistic support will be enhanced.

The expected payoff from on-line testing is projected in Figure 5-7.

It is expected that the addition of on-line testing will not create any degradation in system performance. In fact, without on-line testing, the user tends to use what is commonly referred to as an "Easter egging" for changing parts which he feels may be bad. By constant reshifting of parts in and out of the system without the benefit of testing, the technician is actually degrading the system. Therefore, accurate on-line testing will reduce system degradation potential.

ON-LINE TESTING

(PAYOFF)

	PRESENT RANGE	EXPECTED RANGE
1. PLANNED DIAGNOSTIC CAPABILITY	50-75%	95-100%
2. BIT FALSE ALARM RATE	AS HIGH AS 85%	1-5%
3. RETESTING GOOD UNITS	AS HIGH AS 30%	LESS THAN 1%
4. UNNECESSARY MODULE REMOVAL	30-70%	LESS THAN 1%
5. MANPOWER REQUIREMENTS		REDUCED BY 10%

Figure 5-7. On-Line Testing (Payoff)

Trade-offs between payoff and degradation is certainly positive. The issue is the ability to provide the additional on-line capability without impacting system size/weight, and within an affordable cost. It is expected that the recent advances in technology make on-line testing feasible at this time. Failure to apply this technology will result in complex fielded systems with all the problems which relate to that complexity (particularly manpower problems).

Paybacks of on-line testing take advantage of the fact that the system in its operational state is capable of self-analysis using internal electronics. Similar measurements attempted off-line require that the environment of the system be recreated at great expense in the test equipment consoles.

5.6.1.2 Productivity Improvement and Factory Testing Benefits

The benefits and payoffs of diagnostic improvement in factory testing are quantifiable in terms of "return on investment". In view of this, most U. S. factories have made significant investments in automation leading to improve diagnostics. Specifically, in-circuit testing which provides 100 percent diagnostics (for catastrophic failures) has resulted in increased purchases for that type of equipment, which approaches 200 million dollars since 1980. Most U. S. corporations, which had purchased automatic test equipment using Government contract funds, have now turned to their own investment capital. Return on investment calculations show returns of in excess of 25 percent with many returns of 50 percent for capital equipment used for testing. Productivity gains in the factory are keyed on increased diagnostics which reduce rework costs. This improvement in the factories far exceeds any improvement in yield due to quality circles.

Since the return on investment is so explicit, Government intervention is not required to enjoy this gain in productivity. Embedded support concepts, however, are more difficult to quantify and, therefore, must be secured by the Government through improved specifications.

5.6.2 Productivity Gains Through Off-Line Testing

Service testing, commonly referred to as off-line testing, is usually done at two or three levels of maintenance. These levels include Organizational, Intermediate and Depot Levels. The ability to repair fielded units at forward levels has a direct impact on the amount of spares required to support a specific readiness requirement. Trade-offs of ATE vs. spares has resulted in military deployment of millions of dollars worth of test equipment over the past decade. Based upon lessons learned and recent studies of a major industry group, the Joint Logistics Commanders have instituted an automatic testing plan. A key part of this plan includes specific Services off-line testing programs such as Air Force's MATE (Modular Automatic Test Equipment), Navy's Consolidated Support System (CSS), and the Army's Automatic Test Support System (ATSS) Programs. These programs represent the first major R&D effort in off-line ATE development by the military. Each of these programs attacks a unique set of mission-driven problems. MATE is maturing rapidly and is being institutionalized across the Air Force. The Navy Consolidated Support System is midway in a study phase and will be entering Full-Scale Development in late 1983. The Army Automatic Test Support System is now entering a study phase.

Results to date have shown very specific cost benefits. Due to improved management techniques and reduction in proliferation of new designs, the off-line ATE programs in the Air Force are expected to save at least 100 million dollars per year. Navy studies in Consolidated Support System indicate that personnel savings up to 30 percent will be achieved and throughput will be doubled at carrier I-Level.

5.6.3 Summary Of Benefits

In summary, the combination of embedded test support and off-line testing can have a significant affect on maintenance costs. The reduction will be primarily from reduced repair cost in the field. In addition, rework cost in the factories across the Nation is being drastically

reduced by improved diagnostics. This dual impact of rework cost reduction in the factory and repair cost reduction in the field will drive down both the maintenance costs and the acquisition costs of new systems.

In view of the increased expenditures for new weapons and the escalating acquisition and ownership costs created by this complexity, it is imperative that the recommendations in this report be immediately implemented. The military threat must be met at "affordable cost". The consequence of increased Defense production at "any cost" could be National economic disaster.

SECTION 6. CONCLUSIONS

As a result of this study, the following conclusions have been reached.

6.1 TRADITIONAL WEAPON SYSTEM RELIABILITY AND MAINTAINABILITY DESIGN TECHNIQUES ARE NO LONGER SATISFACTORY

Traditional design techniques for injecting reliability and maintainability technology into weapon systems are no longer satisfactory. Testability and testing requirements must be injected into weapon system operational requirements, requests for proposals, and system specifications beginning at the weapon systems concept formulation stage and continuing throughout the acquisition cycle. These requirements must be specified as "design requirements" and measurable over the acquisition cycle of the weapon system. To accomplish this, we must learn to "speak the language" of the weapon system designer. A "performance over time" concept must replace the "supportability" concept, with "performance over time" equal in importance to performance capability. Effectiveness must have the relationship between performance capability and "performance over time":

$$E \approx P_C \times P_T.$$

To do this, we must learn how to specify P_T. It must be mission-driven and relatable to acquisition and ownership costs.

6.2 IMPROVEMENT IN THE TECHNOLOGY BASE IS REQUIRED

The present technology base does not exist to significantly improve this situation. Tools do not exist to integrate and trade-off various reliability, maintainability and testability elements. While continuing support of off-line testing RDT&E is essential, more emphasis should be placed on embedded testing support, which offers the promise of simplifying the logistics pipeline and minimizing the amount of external test equipment. The era of VHSIC on the horizon necessitates significant investments in testing technology, prior to their use in fielded systems. Means for predicting and demonstrating testing technology payoffs are not sophisticated enough to ascertain their value and to convince weapon systems designers of their utility.

6.3 INJECTING TESTING TECHNOLOGY INTO WEAPON SYSTEMS DESIGNS MUST BE "INSTITUTIONALIZED"

Institutionalizing the injection of testing technology into weapon system designs is not being satisfactorily accomplished. Project managers and their counterparts in industry are not ready to risk involvement in inventing and applying this technology. The analytical tools, documentation, data bases, and educational courses are not adequate to promote across-the-board application of testing technology.

6.4 THE MANAGEMENT OF TESTING TECHNOLOGY REQUIRES IMPROVEMENT

The management of testing technology is not satisfactory and is a major barrier to the success of the program. Responsibility is fractionated both within OSD and within the Services. Over 100 testing technology tasks with 25 different sponsors and 51 performing activities supported by 27 different program elements are symptoms of the problem. The Services are attempting to improve this situation to the degree possible under existing policy and procedures. Both the Navy and the Army have established Testing Technology Strategy Teams to coordinate and guide their programs. All three Services have central focal points for coordination of testing technology effort, but normally do not exert control over the funding. This lack of a home for testing technology is reflected in lack of support for testing technology and clearly inhibits its transitioning from one RDT&E category to the next and, subsequently, its utilization in weapon systems. The funding for testing technology is approximately 50 percent of what is required. At present, testing technology funding support is much less than 1 percent of what is being spent in the testing area today. Industry IR&D is not aimed at solving this problem, but yet is key to solving the transitioning problem; and thus, must be given additional incentives, guidance, and controls to make this happen.

SECTION 7. RECOMMENDATIONS

The following paragraphs are the major recommendations emanating from this study.

7.1 INITIATE A MAJOR WEAPON SYSTEM DESIGN TECHNOLOGY PROGRAM, WHICH INJECTS TESTING TECHNOLOGY INTO THIS DESIGN PROCESS

A major weapon system design technology must be initiated, which injects testing technology into this design process. Methods must be developed for specifying mission-driven testing requirements beginning with weapon system operational requirements and proceeding through the weapon system acquisition cycle. These requirements must be specified as both performance capability and "performance over time" parameters. Tools which can quantify the return on investment for various testing technology alternatives and permit trading-off to determine the proper mix of test strategies, technologies, and equipment must be developed. Measures of effectiveness to quantify the effect of these mixes on operational readiness and manpower requirements are required. This process must be incorporated into the weapon system computer-aided design/logistic support analysis process to insure proper application. Design techniques, which promote testability, must be developed, along with the ability to predict and demonstrate testability quantitatively.

7.2 INVEST IN EXPANDING THE TESTING TECHNOLOGY BASE TO PROVIDE "OFF-THE-SHELF" PROVEN ALTERNATIVES FOR USE IN WEAPON SYSTEM DESIGN

The testing technology base needs to be expanded to provide Government and industry project managers with "off-the-shelf" proven alternatives for use in their designs. Embedded test support should be emphasized including:

a. Development of non-electronic monitoring systems and diagnostic/prognostic techniques.

b. Development of system-level (end-to-end) testing techniques, coupled with operational training procedures as a means for automating effective maintenance, reducing manual testing, and providing on-the-job training.

c. Development of performance monitoring hardware and software to provide command with an information tool for ascertaining the readiness of his weapon systems.

Support of the three Service off-line ATE programs (MATE, CSS, and ATSS) should continue, as an example of successfully transitioning testing technology to advanced and engineering development, and subsequent application to weapon systems.

A formal Integrated Diagnostics program with a goal of 100 percent planned fault detection and fault isolation is required. The present Air Force and Navy emphasis on this concept should be further expanded and adopted by the other Services. This concept is supported by the recommendations emanating from the OSD BIT Workshop and the NSIA Integrated Diagnostics Conference, and thus has both the Service and industry recognition. Issuance of formal OSD and Service policy is required, along with auditing procedures to insure proper implementation. In addition, RDT&E is required for development of BIT technology including "smart BIT", pin electronics, etc. The comprehensive research and development in maintenance aiding should continue with emphasis placed on implementing this technology as an integral part of Integrated Diagnostics. Procedures to promote diagnostic consistency from factory testing through all maintenance and training levels should be developed.

The testing of advanced devices such as VHSIC, bubble memories, charge-coupled devices, etc., should be addressed prior to being incorporated in weapon system designs. Calibration techniques for both manual and automatic testing equipment need to be developed to lessen the calibration load and reduce calibration costs.

Lastly, the test bed concept, supported by a significant advanced development effort, needs to be formalized as a means for synergistically demonstrating and integrating test technology.

7.3 INSTITUTIONALIZING THE TRANSITIONING AND UTILIZATION OF TESTING TECHNOLOGY

To institutionalize transitioning and use of testing technology, it is required that:

a. The series of guidance documents, standards, specifications, and handbooks listed in Table 4-2 must be modified or prepared, as appropriate, for use in the weapon system acquisition process.

b. The testing technology data bases presently available for use are not adequate. Data is required as an input to P_T, return on investment, and testability prediction models. Data to estimate the payoffs from investments in technology is required. Testability feedback of field data is required as a means for updating mission-driven testing requirements.

c. The present Service- and industry-offered courses in automatic testing acquisition and design for testability need to be expanded as indicated in Table 4-2. In addition, a course on ATLAS (IEEE Std. 716) is required.

7.4 INITIATE A SERIES OF ACTIONS TO IMPROVE TESTING TECHNOLOGY MANAGEMENT

The following is a series of required actions to improve the development and application of testing technology:

a. Current management of testing technology RDT&E is fractionated. A single managerial network of testing technology advocates is required extending from OSD through the individual military Services. A single Service manager is not required, but rather a series of focal points beginning at OSD and extending through the lowest managerial levels in the Services, each with appropriate control of funding. These focal points not only should be charged with the responsibility for the testing technology program for their organization, but also have appropriate implementation authority to assure proper application of this technology. They should be charged with "sign-off" authority at appropriate design review points.

b. Integration of testing technology into an overall logistics RDT&E program is required. Fewer program elements, improved integration of logistic effort supported within these program elements and an established schedule for development and transitioning this technology are integral parts of this process.

c. DOD Directives and Instructions 5000.1, 5000.2, and 5000.39, etc., and the Service implementing instructions and regulations should be reviewed to assure adequate attention is paid to testing technology. In particular, testability, as a rigorous design discipline, should be injected into these policy documents. Each Service and OSD should be charged with this review responsibility, with a rigorous schedule established for modification and preparation of appropriate policy documents.

d. A program needs to be established and funded to identify weapon system "bad actors" and take action to improve the reliability and maintainability of these units. Periodic reports should be prepared on the progress being made.

e. Finally, improved incentives for IR&D in testing technology are required. Credit for IR&D effort into proposals should be recognized when evaluating these contractors' proposals.

BIBLIOGRAPHY

1. Application Of Testability Figures Of Merit To The Electronics System Acquisition Process. Final Technical Report, dated 15 May 1981. Contract No. N6021-80-C-A078.

2. Built-In-Test Equipment Requirement Workshop, dated August 1981. Institute for Defense Analysis, P-1600. No. ADA07842.

3. DATAT (Department of the Army TMDE Action Team) Study, covering 3-month period, December 1, 1981 through March 10, 1982.

4. Industry/Joint Services Automatic Test Project. Final Report, dated June 1980.

5. Report Of Industry Ad Hoc Automatic Test Equipment Project For The Navy - Volumes I, II, and III. Dated April 1977. Prepared by Aerospace Industries Association, Electronic Industries Association, National Security Industrial Association, Western Electronic Manufacturers Association, Shipbuilders Council Of America.

6. Report On Navy Issues Concerning Automatic Test, Monitoring And Diagnostic Systems And Equipment. Dated 13 February 1976. For the Assistant Secretary of the Navy (R&D). Prepared by ATE Ad Hoc Working Group.

7. Selection Guide For Digital Test Program Generation Systems (NAVMATP 9493, CARCOMP 70-9, AFLC 800-41, AFSC 800-41, NAVMC 2718) - 1981.

8. Testing And Maintenance Of Weapon Systems May Be Enhanced By The Design For Testability Concept. Letter Report, dated 6 August 1982. GAO Report (MASAD-82-38).

END

FILMED

02-84

DTIC